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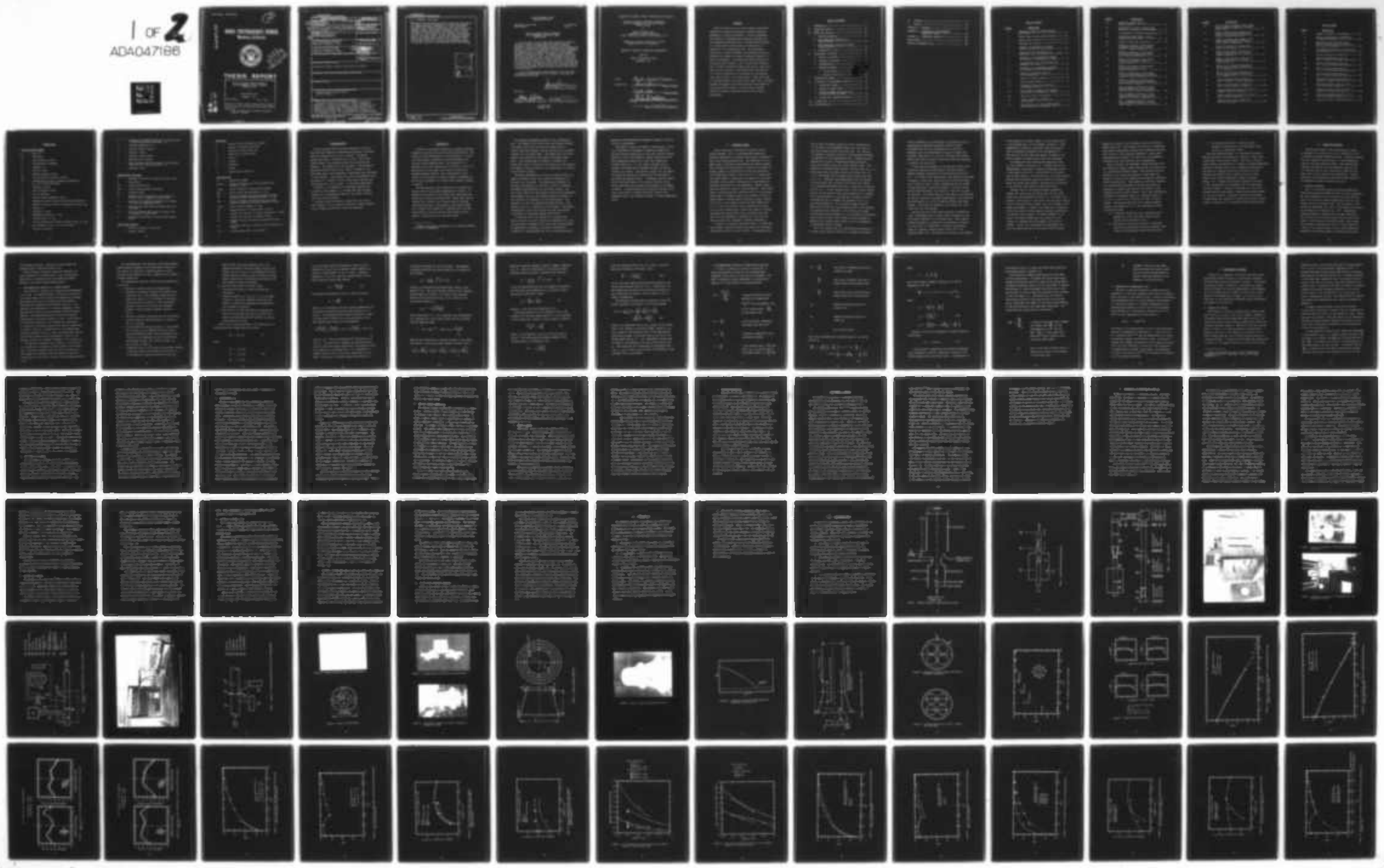

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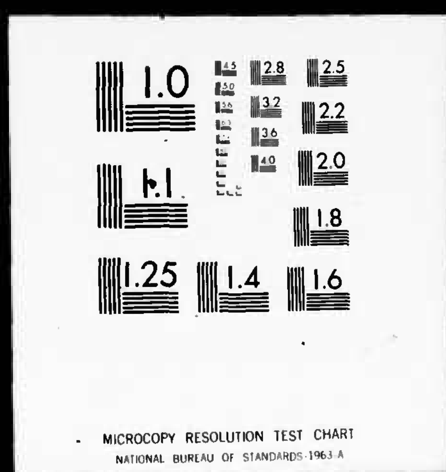

Report Number - NPS-69Pc77092

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NAVAL POSTGRADUATE SCHOOL

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THESIS REPORT

EFFECTS OF SEVERAL GEOMETRIC PARAMETERS
ON THE PERFORMANCE OF A MULTIPLE NOZZLE
EDUCTOR SYSTEM

by

Charles Michael Moss

September 1977

Thesis Advisor: Paul F. Pucci

Approved for public release; distribution unlimited.

Prepared for:
Naval Ship Research and Development Laboratory
Annapolis, Code 2833

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER
14 NPS-69Pc77092

2. GOVT ACCESSION NO.

3. RECIPIENT'S CATALOG NUMBER
9

4. TITLE (and Subtitle)
6 Effects of Several Geometric Parameters on the Performance of a Multiple Nozzle Eductor System•

5. TYPE OF REPORT & PERIOD COVERED
Master's Thesis; September 1977

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s)
10 Charles Michael Moss

8. CONTRACT OR GRANT NUMBER(s)

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Naval Postgraduate School
Monterey, California 93940

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
N00167-76-WR-6-0454

11. CONTROLLING OFFICE NAME AND ADDRESS
Naval Postgraduate School
Monterey, California 93940

12. REPORT DATE
11 Sep [redacted] 77

13. NUMBER OF PAGES
12 189 p.

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)

15. SECURITY CLASS. (of this report)
Unclassified

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Multiple Nozzle Eductor System
Cold Flow Tests

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

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DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE
S/N 0102-014-6601

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

251450

(20. ABSTRACT Continued)

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NTIS	White Section	☑
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The work reported herein has been supported in part by the Naval Ship Research and Development Laboratory, Annapolis, Code 2833; work request N00167-76 WR 6-0454.

Paul F. Pucci
Paul F. Pucci
Professor of Mechanical Engineering

Approved by:

Allen E. Fuhs
Allen E. Fuhs, Chairman
Department of Mechanical Engineering

R. R. Fossum
Dean of Science and Engineering

NPS-69Pc77092
September 1977

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Effects of Several Geometric Parameters on the Performance of a Multiple Nozzle Eductor System

by

Charles Michael Moss
Lieutenant, United States Navy
B.ChE., Georgia Institute of Technology, 1972

Submitted in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE IN MECHANICAL ENGINEERING

from the

NAVAL POSTGRADUATE SCHOOL
September 1977

Author: Charles Michael Moss

Approved by: Paul F. Pucci, Thesis Advisor

Matthew Kelleher, Second Reader

R. E. Newton, Chairman, Department of Mechanical Engineering (Acting)

______________________ Dean of Science and Engineering

ABSTRACT

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NOMENCLATURE

English Letter Symbols

A	-	Area, $in.^2$
AR	-	Area Ratio
c	-	Sonic velocity, ft/sec
C	-	Coefficient of discharge
D	-	Diameter, in.
f	-	Friction factor
Fa	-	Thermal expansion factor
F_{fr}	-	Wall skin-friction force, lbf/ft^2
g_c	-	Proportionality factor in Newton's Second Law, $g_c = 32.174\ lbm\text{-}ft/lbf\text{-}sec^2$
h	-	Enthalpy, Btu/lbm
k	-	Ratio of specific heats
K	-	Flow coefficient
K_e	-	Kinetic energy correction factor
K_m	-	Momentum correction factor at the mixing stack exit
K_p	-	Momentum correction factor at the primary nozzle exit
L	-	Length, in.
P	-	Pressure, in. H_2O
P_a	-	Atmospheric pressure, in. Hg
P_v	-	Velocity head, in. H_2O
PMS	-	Static pressure along length of mixing stack, in. H_2O
R	-	Gas Constant for Air, 53.34 ft-lbf/lbm-°R
s	-	Entropy, Btu/lbm-°R

S - Distance from primary nozzle exit to mixing stack or entrance transition entrance, in.

T - Absolute temperature, °R

u - Internal energy, Btu/lbm

U - Velocity, ft/sec

v - Specific volume, lbm/ft^3

W - Mass flow rate, lbm/sec

x - Axial distance from the entrance to the constant area portion of the mixing stack, in.

Y - Expansion factor

Dimensionless Groupings

A* - Secondary flow area to primary flow area ratio

M - Mach number

ΔP* - Pressure coefficient

PMS* - Mixing stack pressure coefficient

Re - Reynolds number

S/D - Standoff; Ratio of distance from entrance of mixing stack to diameter of mixing stack

T* - Seconda.y flow absolute temperature to primary flow absolute temperature ratio

W* - Secondary mass flow rate to primary mass flow rate ratio

x/D - Ratio of distance from throat of mixing stack to diameter of mixing stack

ρ* - Secondary flow density to primary flow density ratio

Greek Letter Symbols

μ - Absolute viscosity, lbf-sec/ft^2

ρ - Density, lbm/ft^3

Subscripts

0	-	Section within secondary air plenum
1	-	Section at primary nozzle exit
2	-	Section at mixing stack exit
m	-	Mixed flow or mixing stack
or	-	Orifice
p	-	Primary
s	-	Secondary
u	-	Uptake
w	-	Mixing stack inside wall

Tabulated Data

MU	-	Uptake Mach number
PA-PNZ	-	Pressure differential across secondary flow nozzles, in. H_2O
PA-PS	-	Static pressure at mixing stack entrance
PMS	-	Mixing stack static pressure, in. H_2O
PTA	-	Velocity pressure head distribution at mixing stack exit along a diagonal traverse, in. H_2O
PTB	-	Velocity pressure head distribution at mixing stack exit along a horizontal traverse, in. H_2O
PU-PA	-	Static uptake pressure, in. H_2O
UM	-	Average velocity in mixing stack, ft/sec
UP	-	Primary flow velocity at primary nozzle exit, ft/sec
UU	-	Primary flow velocity in uptake, ft/sec
VA	-	Diagonal velocity traverse at mixing stack exit, ft/sec
VB	-	Horizontal velocity traverse at mixing stack exit, ft/sec
VAV	-	Average mixing stack exit velocity

ACKNOWLEDGEMENT

The work reported herein has been supported in part by the Naval Ship Research and Development Laboratory, Annapolis, under the direction of Mr. Olin M. Pearcy. My deepest appreciation goes to Professor Paul F. Pucci, the author's thesis advisor, who patiently guided the way through this research. The assistance of the personnel in the Mechanical Engineering machine shop and Mr. Ronald C. Ramaker of the Wood Model Shop in the Department of Aeronautics was invaluable to this research. The guidance and initial developmental work provided by Lt. Charles R. Ellin, whose thesis research was used extensively in this report, is sincerely appreciated.

Although it is impossible to acknowledge everyone who assisted in this research, it is hoped that those unnamed persons will nevertheless be aware of the author's appreciation for their assistance.

A special thanks and grateful appreciation are due my wife, Rochelle, who although not receiving a degree deserves one for making the difficult times more endurable.

I. INTRODUCTION

Multiple nozzle eductor systems are receiving increased interest for various marine and aviation applications. The subject of this investigation is the application of multiple nozzle eductor systems for cooling the exhaust gas from gas turbine powered ships. This research is an extension of the work reported by Lt. Charles R. Ellin [1][1]. Whereas Ellin's work dealt with specific existing and proposed shipboard systems, this investigation is concerned with the effects of certain geometric parameters on the overall performance of multiple nozzle eductor systems in general.

For the purpose of this investigation the exhaust gas eductor system illustrated schematically in Figure 1, is defined as the portion of the uptake which discharges the exhaust gas (called the primary flow) through four nozzles (primary flow nozzles) into a mixing stack of constant cross sectional area. The purpose of the eductor system is to induce cooler ambient air (secondary air) into the mixing stack to mix with and cool the primary gas flow before it leaves the end of the mixing stack.

---

[1]Numbers in brackets correspond to the reference numbers in the list of references.

The geometric parameters varied in this investigation were: the length of the mixing stack; the distance between the primary flow nozzle exit and the mixing stack or conical transition entrance; and the addition of an entrance transition to the mixing stack. The number and size of the primary flow nozzles was held constant throughout these tests. Ellin established the effects of changing the mixing stack area to primary air flow area ratio and changing the number of primary nozzles on the performance of multiple nozzle eductor systems.

The total performance of an eductor system involves the degree of mixing as well as the amount of secondary air inducted into the system. The experimental technique to determine the ambient air flow rate is first to establish the pumping characteristics of the eductor system. The use of any restrictive type measuring devices for determining the secondary flow rate was avoided because the eductor is very sensitive to secondary air flow restrictions. The secondary air flow was regulated by means external to the eductor so as not to disrupt the flow patterns. The pumping characteristic curve thus obtained was then extrapolated to determine its operating pumping coefficients.

A one-dimensional flow analysis of a single nozzle eductor system, as a unit, facilitates determination of the non-dimensional parameters which govern the flow phenomenon. An experimental correlation of these non-dimensional parameters is then developed and used in evaluating eductor

performance and demonstrating geometric parameter variation effects on performance.

The degree of mixing is evident in several ways. First, it is indicated by the degree of momentum transfer from the high velocity exhaust gas to the lower velocity induced ambient air and in the degree of energy transfer from the high temperature exhaust gas to the lower temperature induced ambient air. In this highly turbulent mixing process, the mechanisms for momentum transfer and energy transfer are similar. Considerable insight into the degree of cooling can therefore be gained from the knowledge of the degree of momentum mixing. A momentum correction factor can be calculated based on the velocity profiles at the mixing stack exit and was used as one measure of the degree of mixing. A second measure of the degree of mixing is the ratio of the peak to average velocities, which by the reasoning above, also reflects the peak to average temperature ratios.

II. LITERATURE SURVEY

Little literature is available on multiple nozzle eductor systems. Ellin [1] provides some research of practical importance on multiple nozzle eductor systems for use on gas turbine powered ships. He conducted cold flow model tests of multiple nozzle exhaust gas eductor systems with constant area mixing stacks to evaluate the effects of several geometric configurations on eductor performance. A one dimensional analysis from Pucci [2] of a simple eductor system based on conservation of momentum for an incompressible gas was used in determining the non-dimensional parameters governing the flow phenomenon. Eductor performance was defined in terms of these parameters. Three basic eductor configurations were tested by Ellin [1] with mixing stack length to diameter ratios, L/D, between 2.3 and 2.8, mixing stack to primary nozzle area ratios, A_m/A_p, ranging from 2.28 to 3.03, primary nozzle exit Mach numbers from 0.07 to 0.265, and primary nozzle combinations of three, four, and five nozzles each. Within the range of variables considered the mixing stack area to primary nozzle area ratio and the resistance to secondary air flow into the eductor had the most influence on eductor performance.

A Society of Automotive Engineers report [3] identifies basic eductor equations through the analysis of an eductor system used to cool an engine nacelle. The approach taken

was to treat the eductor system as a unit, concentrating on the overall flow phenomenon rather than the details of the mixing process within the mixing tube. R.S. Darling [4] combined a computer solution of the equations developed in reference [3] with experimental data to demonstrate the feasibility of using a single nozzle eductor system on naval ship stacks to cool gas turbine exhaust gases. The geometries considered were confined to mixing stack $L/D \leq 1.6$, mixing stack area to primary nozzle area ratios from 1.53 to 2.34 and uptake area to primary nozzle area ratios from 1.0 to 1.5. Darling's study demonstrates that an increase in mixing stack area to primary nozzle area ratio results in an increased secondary flow rate, a trend that is verified by Ellin [1]. It also indicates that a single nozzle eductor system, for the range of area ratios tested and at a primary flow rate equivalent to that used here, produces little or no secondary flow at secondary air pressures equal to or less than atmospheric. For an eductor system utilized aboard ship to cool gas turbine exhaust gases, such secondary air pressures are encountered. R.S. Darling also tested two multiple-eductor systems, not to be confused with multiple-nozzle eductor systems, which showed a slight increase in pumping over a single eductor system but at the expense of a considerable weight increase.

Pucci [2] improved upon the one-dimensional analysis of a single nozzle eductor system with a constant area mixing

stack by combining a one-dimensional flow analysis with an experimentally determined momentum correction factor. He demonstrated that the performance of an eductor is dependent upon the completeness of mixing of primary and secondary flows which is a function of mixing stack length, mixing stack area to primary nozzle area ratio and secondary to primary flow rate ratio.

A review and bibliography on jet pump and ejector technology was prepared and published by the British Hydrodynamics Research Association, Fluid Engineering Division [5]. It is based on the association's own records of published literature in this area, records which have been maintained over a period of some 30 years, supplemented by the outcome of some additional literature searching. The short review section describes many of the variety of uses for jet pumps and ejectors. The review section is followed by a bibliography of some 400 references arranged chronologically with abstracts. The bibliography is in turn followed by subject and author indexes. The following references, [6] through [14], were found from this bibliography.

Vyas and Kar [6] of the Indian Institute of Technology, India, experimented with a single nozzle configuration with no entrance transition to the mixing stack. Their results showed the pumping, as defined by the secondary to primary air flow ratio, is independent of primary flow Reynolds number for Reynolds numbers greater than 2×10^4. The Reynolds number, Vd/ν, was based on the velocity and diameter

of the primary flow uptake (where V is the velocity and d is the diameter and ν is the kinematic viscosity). This independence of pumping on Reynolds number was found by other investigators including Ricou and Spalding [7]. Vyas and Kar [6] also found the pumping increased as the mixing chamber to primary nozzle area ratio increased.

An extension of the investigation reported by Pucci [2] was conducted by Mitchell [8]. Mitchell empirically demonstrated a correlation of eductor performance similar to that used by Ellin [1]. He found that with a nozzle type entrance region to the mixing stack, an optimum pumping occured when the primary nozzle exit plane was located at about one mixing stack diameter upstream from the entrance to the constant area section of the mixing stack.

Another study of the optimum distance between the primary flow nozzle and the mixing stack for the single nozzle case was performed by Putilov [9]. He found, like Mitchell, that removal of the nozzle from the initial section of the cylindrical mixing chamber led to an increase in the pumping performance. However, the latter only increased on moving the nozzle a certain specific distance, after which it remained fairly constan. On further movement of the nozzle, the pumping coefficient fell abruptly as the primary jet expanded past the diameter of the mixing chamber. Putilov also concluded from experimental work that the optimum distance of the nozzle from the mixing

chamber is a function of the primary nozzle to the mixing chamber area ratio. Both Mitchell and Putilov's conclusions were based on experimental findings with geometries and flow rates similar to the elliptical transition, single nozzle experimentation of Harrell [10] which will be discussed in correlation with the results of this investigation.

Fabris and Fejer [11] performed a study that dealt with the transfer of kinetic energy from an array of primary jets to a surrounding secondary stream. They explored the basic features of such flows and examined to what extent the results of single nozzle research may be applied to multiple nozzle configurations. They present an analytical technique for estimating the performance of multiple nozzles and examined in a special test facility the validity of the assumptions used in their analysis. Their test configuration consisted of a hexagonal array of 31 primary nozzles of 1.27 cm (0.5 inch) ID in a 30.48 cm (12 inch) ID mixing chamber. The analysis made use of an integral momentum analysis from Abramovich [12]. The conclusions of their investigation were:

(a) A confined multiple jet with a hexagonal array behaved not unlike individual coaxial mixing regions with frictionless walls.

(b) The length of the mixing regions of a multiple nozzle was significantly shortened compared to the length of the equivalent coaxial single nozzle.

(c) The mixing efficiency of a multiple nozzle exceeded the efficiency of the equivalent single nozzle by a significant amount.

Arbel and Manheimer-Timnat [13] calculated the performance of multiple nozzle eductors by means of a model using an equivalent single nozzle device. The flow in the equivalent eductor was described by a system of integro-differential equations, obtained under a set of appropriate assumptions. They devised a computer program for the solution of the equations and compared their results for single nozzle eductors with various experimental results including Mikhail [14]. Pressure distributions obtained by the use of their program gave good agreement with the experimental results of Mikhail. Primary to secondary air flow ratios deviated from the experimental values by about seven percent for the case selected. Additional results were presented to demonstrate the capability of analyzing a multiple nozzle system by reducing it to an equivalent single nozzle system.

III. THEORY AND ANALYSIS

As previously stated, this investigation is almost an extension of the work by Ellin [1], differing in that no specific prototype modeling was done. Similarity between the basic geometry tested by Ellin [1] was maintained in order to correlate data with others. The dimensionless groupings controlling the flow phenomenon used by Ellin [1] were also used in this investigation along with the basic means of data analysis and presentation. Dynamic similarity was maintained by using Mach number similarity to establish the model's primary flow rate.

A. MODELING TECHNIQUE

Ellin [1] maintained dynamic similarity between the model and prototype by duplicating the flow while accounting for the differences in fluid properties arising from the use of air at or near ambient temperature in place of hot exhaust gas for the primary flow. For the region of flow velocities considered, the state of the primary flow throughout the eductor is turbulent ($R_e \approx 10^5$). Consequently, momentum exchange is predominant over shear interaction and the kinetic and internal energy terms are more influential on the flow than are viscous forces. Mach number can be shown to represent the ratio of kinetic energy of a flow to its internal energy, and is a more significant parameter than Reynolds number in describing the primary

flow through the uptake. Similarity of Mach number was therefore used to model the primary flow.

While not exactly modeling a specific prototype, the basic dimensions of the model used in this investigation were kept to a reasonable scale of exhaust gas eductor systems in use on gas turbine powered ships.

B. ONE-DIMENSIONAL ANALYSIS OF A SIMPLE EDUCTOR

The theoretical analysis of an eductor may be approached in two ways. One method attempts to analyze the details of the mixing process of the primary and secondary air streams which takes place inside the mixing stack and thereby determines the parameters which describe the flow. This requires an interpretation of the mixing phenomenon, which, when applied to multiple nozzle systems, becomes extremely complex. The method employed here analyzes the overall performance of the eductor system as a unit. Since details of the mixing process are not considered in this method, an analysis of the simple single nozzle eductor system shown in Figure 2 leads to a determination of the dimensionless groupings governing the flow. This one-dimensional analysis follows very closely that of references [1] and [2], the details of which are included in Appendix A of reference [1].

The driving or primary fluid, flowing at a rate W_p and at a velocity U_p, discharges into the throat of the mixing-tube, inducing a secondary flow rate of W_s at velocity U_s. The primary and secondary flows are mixed and leave the mixing-tube at a flow rate of W_m and a bulk-averaged velocity of U_m.

The one-dimensional flow analysis of the simple eductor system described depends on the simultaneous solution of the equation of continuity, momentum equation, energy balance and the equation of state, compatible with specific boundary conditions.

The idealizations made for simplifying the analysis are as follows:

1. The flow is steady state and incompressible.
2. Adiabatic flow exists throughout the eductor with isentropic flow of the secondary stream from the plenum (at section 0) to the throat or entrance of the mixing-tube (at section 1) and irreversible adiabatic mixing of the primary and secondary streams in the mixing-tube (between sections 1 and 2).
3. The static pressure across the flow at the entrance and exit planes of the mixing-tube (at sections 1 and 2) is uniform.
4. At the mixing-tube entrance (section 1) the primary flow velocity U_p and temperature T_p are uniform across the primary stream, and the secondary flow velocity U_s and temperature T_s are uniform across the secondary stream; but U_p does not equal U_s, and T_p does not equal T_s.
5. Incomplete mixing of the primary and secondary streams in the mixing-tube is accounted for by the use of a non-dimensional momentum correction factor K_m

which relates the actual momentum rate to the pseudo-rate based on the bulk-average velocity and density and by the use of a non-dimensional kinetic energy correction factor K_e which relates the actual kinetic energy rate to the pseudo-rate based on the bulk-average velocity and density.

6. Both gas flows behave as perfect gases.
7. Flow potential energy of position changes are negligible.
8. Pressure changes P_{so} to P_{s1} and P_1 to P_a are small relative to the static pressure so that the gas density is essentially dependent upon temperature (and atmospheric pressure).
9. Wall friction in the mixing-tube is accounted for with the conventional pipe friction factor term based on the bulk-average flow velocity U_m and the mixing-tube wall area A_w.

Based on the continuity equation, the conservation of mass principle for steady state flow yields

$$W_m = W_p + W_s \tag{1}$$

where

$$\begin{aligned} W_p &= \rho_p U_p A_p \\ W_s &= \rho_s U_s A_s \\ W_m &= \rho_m U_m A_m \end{aligned} \tag{1a}$$

All of the above velocity and density terms, with the exception of ρ_m and U_m, are defined without ambiguity by virtue of idealizations (3) and (4) above. Combining equations (1) and (1a), the bulk average velocity at any point along the mixing stack becomes

$$U_m = \frac{W_s + W_p}{\rho_m A_m} \tag{1b}$$

The perfect gas equation of state is used to evaluate

$$\rho_m = \frac{P_a}{R T_m} \tag{2}$$

where T_m is calculated as the bulk average temperature for the mixed flow obtained from the *energy* equation (9) to follow. The momentum equation stems from Newton's Second and Third Laws of Motion and is the conventional force and momentum-rate balance in fluid mechanics

$$K_p \left[\frac{W_p U_p}{g_c}\right]_1 + \left[\frac{W_s U_s}{g_c}\right]_1 + P_1 A_1 = K_m \left[\frac{W_m U_m}{g_c}\right]_2 + P_2 A_2 + F_{fr} \tag{3}$$

with $A_1 = A_2$. Note the introduction of idealizations (3) and (5). To account for a possible non-uniform velocity profile across the primary nozzle exit, the momentum correction factor K_p is introduced here. It is defined in a manner similar to that of K_m and by idealization (4) is equal to unity but is carried through this analysis to

illustrate its effect on the final result. The momentum correction factor for the mixing stack exit is defined by the relation

$$K_m = \frac{1}{W_m U_m} \int_0^{A_m} U_2^{\,2} \rho_2 \, dA \qquad (4)$$

where U_m is evaluated as the bulk-average velocity from equation (1b). The actual variable velocity and a weighted average density at section 2 are used in the integrand. The wall skin-friction force F_{fr} can be related to the flow stream velocity by

$$F_{fr} = f\, A_w \left[\frac{U_m^{\,2}\, \rho_m}{2\, g_c}\right] \qquad (5)$$

using idealization (9). As a reasonably good approximation for turbulent flow, the friction factor may be calculated from the Reynolds number

$$f = 0.046\, (Re_m)^{-0.2}, \quad \text{where} \quad Re_m = \frac{\rho_m\, U_m\, D_m}{\mu_m} \qquad (6)$$

Applying the conservation of energy principle to the steady flow system in the mixing stack (between sections 1 and 2),

$$W_p \left[h_p + \frac{U_p^{\,2}}{2\, g_c}\right]_1 + W_s \left[h_s + \frac{U_s^{\,2}}{2\, g_c}\right]_1 = W_m \left[h_m + K_e \frac{U_m^{\,2}}{2\, g_c}\right]_2 \qquad (7)$$

neglecting potential energy of position changes, idealization (7). Note the introduction of the kinetic energy correction factor K_e which is defined by the relation

$$K_e = \frac{1}{W_m U_m^2} \int_0^{A_m} U_2^3 \rho_2 \, dA. \qquad (8)$$

It may be demonstrated that for the purpose of evaluating the mixed mean flow temperature T_m, the kinetic energy terms may be neglected to yield

$$h_m = \frac{W_p}{W_m} h_p + \frac{W_s}{W_m} h_s \qquad (9)$$

where $T_m = \phi(h_m)$ only with idealization (6).

The energy equation for the isentropic flow of the secondary air from the plenum (section 0) to the entrance of the mixing stack (section 1) may be shown to reduce to

$$\frac{P_0 - P_1}{\rho_s} = \frac{U_s^2}{2 g_c} \qquad (10)$$

where, in this equation, P_0 and P_1 both have units of lbf/ft^2. This comes from the steady, adiabatic flow, energy equation in differential form

$$dh = -d\left(\frac{U_s^2}{2 g_c}\right)$$

with the recognition that $T\,ds = dh - \frac{1}{\rho}\,dP = 0$ for the postulated isentropic conditions. Thus

$$\frac{dP}{\rho} = -\,d\left(\frac{U^2}{2\,g_c}\right) \tag{10a}$$

But for the small pressure change from the plenum to the mixing stack entrance (section 0 to 1), idealization (8), the temperature and density are essentially constant so that integration of equation (10a) to equation (10) is readily accomplished.

The foregoing equations may be combined to yield the vacuum produced by the eductor in the plenum chamber

$$P_a - P_0 = \frac{1}{g_c\,A_m}\left\{K_p\,\frac{W_p^{\,2}}{A_p\rho_p} + \frac{W_s^{\,2}}{A_s\,\rho_s}\left[1 - \frac{1}{2}\,\frac{A_m}{A_s}\right] - \frac{W_m^{\,2}}{A_m\rho_m}\left[K_m + \frac{f}{2}\,\frac{A_w}{A_m}\right]\right\} \tag{11}$$

where it is understood that A_p and ρ_p apply to the primary flow at the entrance to the mixing stack (section 1), A_s and ρ_s apply to the secondary flow at this same section, and A_m and ρ_m apply to the mixed flow at the exit of the mixing stack (section 2). P_a is atmospheric pressure and is equal to the pressure at the exit of the mixing stack P_2. This equation also incorporates the assumption that $(\rho_s)_1 = (\rho_s)_0$ so that ρ_s may be taken as the density of the secondary flow in the plenum.

C. NON-DIMENSIONAL SOLUTION OF SIMPLE EDUCTOR ANALYSIS

In order to provide the criteria of similarity of flows with geometric similarity, the non-dimensional parameters which govern the flow must be determined. One means of determining these parameters is by normalizing equation (11) which leads to the following terms:

$$\Delta P^* = \frac{\dfrac{P_s - P_0}{\rho_s}}{\dfrac{U_p^{\,2}}{2\, g_c}}$$

a pressure coefficient which compares the "pumped head" $\dfrac{P_a - P_0}{\rho_s}$ for the secondary flow to the "driving head" $\dfrac{U_p^{\,2}}{2\, g_c}$ of the primary flow.

$$W^* = \frac{W_s}{W_p}$$

a flow rate ratio, secondary-to-primary mass flow rate.

$$T^* = \frac{T_s}{T_p}$$

an absolute temperature ratio, secondary-to-primary.

$$\rho^* = \frac{\rho_s}{\rho_p}$$

a flow density ratio. Note that since $P_s = P_p$ and the fluids are perfect gases $\rho^* = \dfrac{T_p}{T_s} = \dfrac{1}{T^*}$.

$A^* = \frac{A_s}{A_p}$ area ratio of secondary flow area to primary flow area

$\frac{A_p}{A_m}$ area ratio of primary flow area to mixing stack cross sectional area

$\frac{A_w}{A_m}$ area ratio of wall friction area to mixing stack cross sectional area

K_p momentum correction factor for primary flow

K_m momentum correction factor for mixed flow

f wall friction factor

With these non-dimensional groupings, equation (11) may be written as

$$\frac{\Delta P^*}{T^*} = 2 \frac{A_p}{A_m} \left\{ \left[K_p - \frac{A_p}{A_m} \beta \right] - W^* \quad 1 + T^* \quad \frac{A_p}{A_m} \beta \right.$$

$$\left. + W^{*2} T^* \left[\frac{1}{A^*} \quad 1 - \frac{A_m}{2A^* A_p} \quad - \frac{A_p}{A_m} \beta \right] \right\}$$

(11a)

where

$$\beta = K_m + \frac{f}{2} \frac{A_w}{A_m} .$$

For a given eductor geometry, equation (11a) may be expressed in the form

$$\frac{\Delta P^*}{T^*} = C_1 + C_2 W^* (T^* + 1) + C_3 W^{*2} T^* \tag{11b}$$

where

$$C_1 = 2 \frac{A_p}{A_m} \left(K_p - \frac{A_p}{A_m} \beta \right)$$

$$C_2 = -2 \left(\frac{A_p}{A_m} \right)^2 \beta \tag{11c}$$

$$C_3 = 2 \frac{A_p}{A_m} \left\{ \frac{1}{A^*} \quad 1 - \frac{A_m}{2 A^* A_p} \beta - \frac{A_p}{A_m} \beta \right\}$$

Equation (11b) may be expressed as a simple functional relationship

$$\Delta P^* = F(W^*, T^*) . \tag{12}$$

A second means of determining the governing dimensionless parameters is through a dimensional analysis of the mixing process within the mixing stack. A presentation of

this method by Ellin [1] yields the same simple functional relationship found in equation (12).

Three additional dimensionless quantities were added to this investigation. To present the mixing stack static pressure distribution along the length of the mixing stack, a pressure coefficient similar to ΔP^* called PMS* is defined. The distance, S, from the primary flow nozzle exit to the mixing stack or conical transition entrance and the distance, x, from the throat (i.e., the entrance to the constant cross section portion of the mixing stack) of the mixing stack, normalized with respect to the mixing stack diameter, D, were also defined as non-dimensional quantities. The three additional quantities are listed below:

$$PMS^* = \frac{\frac{PMS}{\rho_s}}{\frac{U_p^2}{2\,g_c}}$$

a pressure coefficient which compares the "pumped head" $\frac{PMS}{\rho_s}$ for the secondary flow to the "driving head" $\frac{U_p^2}{2\,g_c}$ of the primary flow, where PMS = static pressure along the mixing stack length.

$\frac{x}{D}$ ratio of the axial distance from the mixing stack throat to the diameter of the mixing stack.

$\frac{S}{D}$ standoff; the ratio of the axial distance between the primary nozzle exit plane and the mixing stack or conical transition entrance to the diameter of the mixing stack.

D. CORRELATION OF EXPERIMENTAL DATA

The ratio of absolute secondary to primary flow temperatures T* is the only parameter which was not controlled during the test of the eductor system. A means of presenting the experimental data for a given geometric configuration in a form which results in a pseudo-independence of the dimensionless groupings P* and W* upon T* was developed. From reference [1] a satisfactory correlation of P*, T* and W* for all temperatures and flow rates is

$$\Delta P^*/T^* \quad = \quad \phi(W^*T^{*0.44})$$

The details of the determination of 0.44 as the correlating exponent are presented in reference [1]. A plot of $\Delta P^*/T^*$ as a function of $W^*T^{*0.44}$ from the experimental data yields the eductor's pumping characteristic curve. Variations in geometry will change the appearance of the pumping characteristic curve and facilitate a direct one to one comparison of pumping ability between various models and prototypes. For ease of discussion, $W^*T^{*0.44}$ will henceforth be referred to as the pumping coefficient.

IV. EXPERIMENTAL APPARATUS

Primary air is supplied to the nozzle and mixing stack system being tested by means of a centrifugal compressor and associated ducting illustrated in Figure 3. The eductor system being tested is mounted in a secondary air plenum which facilitates the accurate measurement of the secondary air flow through the use of ASME long radius flow nozzles mounted on the secondary air plenum. An orifice in the inlet duct to the centrifugal compressor permits measurement of primary air flow rates.[2]

A. PRIMARY AIR SYSTEM

The primary air ducting is constructed of 16-gage steel with 0.635 cm (0.25 inch) thick steel flanges. Assembly of the ducting sections was accomplished using 0.635 cm (0.25 inch) bolts with air drying silicon rubber seals between the flanges of adjacent sections. Entrance to the inlet ducting, shown in Figure 3, is from the exterior of the building through a 91.44 cm (3.0 ft) square to a 30.48 cm (1.0 ft) square reducer 1 each side of which has the curvature of a quarter ellipse. A transition section 2 then changes the 30.48 cm (1.0 ft) square section to a 35.31 cm (13.90 inch)

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[2]Much of the apparatus used in this research was previously used by Lt. Charles R. Ellin in his thesis research [1].

diameter circular cross section (3) which runs approximately 9.14 m (30 ft) to the centrifugal compressor inlet. A standard ASME square edged orifice (4) located 15 diameters downstream of the entrance reducer and 11 diameters upstream of the centrifugal compressor inlet, thus ensuring stabilization of the flow at both the orifice and centrifugal compressor inlet. Piezometer rings (5) are located one diameter upstream and one-half diameter downstream of the orifice. The duct section just downstream of the orifice also contains a thermocouple tap (6). The formulae used to calculate the primary and secondary mass flow rates are presented in Appendix A.

A manually operated double sliding plate variable orifice (7) was designed to constrict the flow symmetrically and facilitate fine control of the primary air flow. During operation the butterfly valve (9) located at the compressor's discharge provided adequate regulation of primary air flow rates, thus eliminating the necessity of the sliding plate valve for flow regulation.

On the compressor discharge side, immediately downstream of the butterfly valve, is a round to square transition (10) followed by a 90 degree elbow (11) and a straight section of duct (12). All ducting to this point is considered part of the fixed primary air supply system. A transition section (13) is fitted to this last square section which reduces the duct cross section to a circular 29.72 cm (11.7 inch)

diameter cross section. This circular ducting provides the primary air inlet to the eductor system being tested. The transition is located far enough upstream of the model to ensure that the flow reaching the model is fully developed.

The centrifugal compressor 8 used to induce primary air to the system is a Spencer Turbo Compressor, catalogue number 25100-H, rated 6000 cfm at 2.5 psi back pressure. The compressor is driven by a three phase, 440 volt 100 hp motor. Primary flow is measured by means of a standard ASME square edge orifice designed to the specifications given in the ASME power test code [15]. The 17.53 cm (6.902 inch) diameter orifice was made of type 304 stainless steel, 0.635 cm (0.25 inch) thick. The inside diameter of the duct at the orifice is 35.31 cm (13.90 inch), which yields a beta ($\beta = d/D$) of 0.497. The orifice diameter was chosen to give the best performance in regards to pressure drop and pressure loss across the orifice over the range of primary air flow rates tested (between the extremes of .907 kg/sec (2.0 lbm/sec) and 1.814 kg/sec (4.0 lbm/sec)).

B. SECONDARY AIR PLENUM

The secondary air plenum, pictured in Figure 4, is constructed of 1.905 cm (.75 inch) plywood and measures 1.22m x 1.22m x 2.44m (4ft x 4ft x 8ft). It serves as an enclosure that completely surrounds the eductor system but allows the system's mixing stack to protrude through a removable plate placed over the plenum's open end. The

purpose of the secondary air plenum is to serve as a boundary through which secondary air induced by the eductor system being tested must flow. Long radius ASME flow nozzles designed in accordance with ASME power test code [15] and constructed of fiberglass penetrate the secondary air plenum boundary, thereby providing the sole means for secondary air to reach the eductor. Appendix D of reference [1] outlines the design and construction of the secondary air flow nozzles. By measuring the temperature of the secondary air and its pressure as it flows through the ASME flow nozzles, its mass flow rate is readily obtained. Flexibility is provided this secondary air flow measuring system by employment of three different flow nozzle sizes: Four of 20.32 cm (8 inch) throat diameter, three of 10.16 cm (4 inch) throat diameter, and three of 5.08 cm (2 inch) throat diameter, various combinations of which produce a wide variety of secondary cross sectional flow areas.

A double screen is installed 1.22 m (4ft) from the open end of the secondary air plenum between the ASME long radius nozzles and the primary air exhaust nozzles. The purpose of the screen is to reduce any swirl effect that could result when only a small secondary air flow area exists. The interior of the secondary air plenum is pictured in Figure 5. Mounted inside the plenum box is the support brackets for the eductor system mixing stack. Adjustments to the mixing stack can be made through an access door in the side of the

plenum, and the removable end plate makes it possible to change mixing stacks.

C. INSTRUMENTATION

Pressure instrumentation was provided for measuring gage pressures inside the secondary air plenum, inside the primary air uptake just prior to the nozzles, and at half diameter distances starting at the entrance on the mixing stack. Atmospheric pressure was measured using a mercury barometer. All other pressures were measured with either U-tube water manometers or inclined manometers with oil of specific gravity 0.834 as the working fluid. The pressure measurement system is pictured in Figure 6 and schematically represented in Figure 7. Rapid and frequent monitoring of each of the various pressures was facilitated by the Scanivalve which was used to scan each pressure tap. A multiple valve manifold is then used to link the single output of the Scanivalve to a bank of instruments consisting of 30.48 cm (12 inch), 7.62 cm (3 inch), 5.08 cm (2 inch), and 1.27 cm (0.5 inch) inclined manometers. This permits better matching of the pressure being measured to an instrument of compatible range, thereby improving the degree of accuracy for lower pressure measurements. Initially a 1.0 PSIG pressure transducer coupled with a KAMAN digital display, model number K 3101A23 pictured in Figure 8, was used in conjunction with the scanivalve. This system was replaced by the bank of water manometers when it was discovered that the transducer

could not measure very low pressures with the desired degree of accuracy. The primary air static pressure just upstream of the nozzles was measured with a 43.18 cm (17 inch) single column water manometer. Figure 9 illustrates the instrumentation for obtaining the data necessary to calculate the primary mass flow rate. A 7.62 cm (3 inch) inclined water manometer is used to measure the static pressure upstream of the orifice, and a 127 cm (50 inch) water u-tube manometer is used to measure the pressure differential across the orifice.

Primary air temperatures at the orifice outlet and just upstream of the model were measured with copper-constantan thermocouples. The thermocouples are in assemblies manufactured by Honeywell under the trade name Megapak. The Megapack consists of a "head" for connecting the extension wires, a "sheath" of 0.318 cm (.125 inch) stainless steel tubing through which insulated leads pass to the exposed measuring junction at the end of the sheath. Polyvinyl covered 20 - gage copper constantan extension wire was used to connect the thermocouples to a Newport digital pyrometer model number 267 which provides a digital display of the measured temperature. Secondary or ambient air temperature is measured with a mercury-glass thermometer and recorded in degrees Fahrenheit.

Velocity profiles at the mixing stack exit were obtained using a pitot-static tube mounted so as to facilitate traversing the entire diameter of the mixing stack. Static

and stagnation pressure pickups from the pitot-static tube were connected to opposite ends of either a 30.48 cm (12 inch) or a 7.62 cm (3 inch) inclined manometer as appropriate for the flow rate tested.

D. EDUCTOR SYSTEM GEOMETRIES

The eductor systems investigated consisted of a single uptake, a single cluster of four primary air flow nozzles of constant cross section, and a single mixing stack. In order to obtain general data on the effects of changes in certain geometric parameters, a simple open configuration was used. No attempt was made to model existing or proposed systems. The simpler open configuration of this investigation was not restricted by the structural constraints of a funnel simulating the ships superstructure. The variables in this research were the mixing stack length and the effect of the entrance region geometry. The applicability to eductor systems to be used on ships was a consideration that influenced the dimensions of the nozzles and mixing stacks. Mixing stack lengths of two and three diameters were investigated which is about the limits of practical stack lengths for a prototype. An entrance transition of conical geometry was added to the mixing stacks to test the effect of a variable entrance region cross section.

Ellin [1] found that while the performance of an eductor system increased when the number of primary flow nozzles was increased from three to four, little improvement

was realized when the number of nozzles was increased to five. The circular configuration of four primary flow nozzles of constant cross section and a ratio of mixing stack area to primary air flow area of 3.0 was chosen as a constant for this investigation. The nozzle configuration is pictured in Figure 10 and a dimensional layout is given in Figure 11. The area ratio chosen for this investigation corresponds approximately to the area ratio used on an existing gas turbine powered ship and was previously investigated by Ellin [1].

1. Mixing Stacks

The mixing stacks tested were manufactured of 29.72 cm (11.7 inch) inside diameter plastic pipe with a 0.51 cm (0.2 inch) wall thickness. Additional material was glued to one of the pipe in order to give enough thickness to cut an approximately 1.25 cm (0.5 inch) radius to give a smooth entrance for the mixing stacks to be tested without the entrance transition. Two different lengths of mixing stacks were tested without an entrance transition: one, two diameters long and one, three diameters long. Pressure taps were located at half diameter locations starting with the entrance to the mixing stack.

The mixing stacks were supported inside the secondary air plenum by means of two adjustable support brackets. These brackets were constructed of 5.08 cm x 5.08 cm (2 x 2 inch) aluminum angle and 1.91 cm (0.75 inch) aluminum plate.

The mixing stack is held in place by two adjustable metal bands. The support brackets were constructed for ease in changing mixing stacks and changing of the standoff distance, i.e., the distance between the primary air flow nozzle exit and the mixing stack entrance. Two additional design criteria for the mixing stack support brackets were the minimum blockage of air flow and, most important, the ease of alignment with the primary air flow nozzles.

The alignment with the primary air flow nozzles was accomplished with the use of the alignment plugs pictured in Figure 13. The two plugs that fit inside of the mixing stack were cut to the exact inside diameter of the mixing stack from 3.81 cm (1.50 inch) thick wood with a 1.91 cm (0.75 inch) diameter hole drilled through the center. A 1.91 cm (0.75 inch) wooden form cut to fit over the end of the primary air flow nozzles also had a 1.91 cm (0.75 inch) diameter hole through the center. The wooden mounting board for the primary air nozzles had a similar hole halfway through its thickness. A straight 1.91 cm (0.75 inch) diameter rod was passed through the center holes of these alignment blocks. Adjustments to the alignment were made with the adjustable bolts on the support brackets until the rod passed freely through the four alignment holes. Figure 14 shows the mixing stack mounted on the support bracket with the alignment plugs and centering rod in place.

2. Entrance Transition

The entrance transition tested is of a conical design as illustrated in Figure 15 and Figure 12. The purpose of the transition was to test the effects of a converging type of entrance region on the performance and mixing of the eductor system. The transition was manufactured from 0.318 cm (0.125 inch) aluminum sheet metal formed into a truncated cone and welded to an eight bolt flange 0.64 cm (0.25 inch) thick and 5.08 cm (2 inch) wide. The total length of the transition is one mixing stack inside diameter with a contraction from $1\frac{1}{2}$ diameters at the entrance to 1 diameter at the exit into the pipe. The entrance to the transition was rounded to remove the sharp corner. A 3.81 cm (1.5 inch) diameter rubber hose was then glued to this entrance region to give a better rounded entrance. Tape and coats of fiberglass finishing coat were then applied to give a smooth rounded entrance.

The transition bolted to a one diameter length mixing stack to give a total length of two diameters is shown in Figure 16 and with the mixing stacks without a transition in Figure 12. The transition was bolted to two different lengths of pipe to form mixing stacks of total length two and three diameters. Pressure taps were located at the transition entrance and at a half diameter from the entrance.

V. EXPERIMENTAL METHOD

Evaluation of an eductor's performance requires determination of the secondary air flow rate as well as the degree of mixing of primary and secondary flows.

The pumping coefficient, $W^*T^{*0.44}$ provides the basis for the analysis of parameter variation effects on eductor pumping. Figure 17 graphically illustrates the eductor pumping characteristic curve defined by the experimental data correlation of equation (13). Design of the experimental apparatus facilitates determination of the dimensionless parameters in the experimental correlation with the exception of the secondary flow rate at the operating point. Any attempt to equip the model with secondary air flow measurement devices restricts the flow rate and does not yield the dynamically similar flow desired. The technique of determining the pumping coefficient at the operating point is first to establish the pumping characteristics of the eductor system. This is accomplished by varying the secondary air flow rate from zero to its maximum measurable value, using the ASME flow nozzles mounted in the secondary air plenum and recording the temperatures and pressures required to calculate the corresponding dimensionless parameters. The "open to the environment" condition is then simulated by removal of the end plate on the secondary air plenum. Extrapolation of the characteristic curve to its intersection

with the $W^*T^{*.44}$ axis locates the pumping coefficient for the operating point of the eductor system.

The mixing stack axial static pressure distribution was obtained from a series of pressure taps at half diameter distances along the mixing stack. The mixing stack was then rotated 45° to place the pressure taps in another position relative to the primary nozzle alignment. The non-dimensional pressure distribution is then plotted versus X/D for each geometry tested. The coordinate system used for the experimentation and presentation of data is illustrated in Figure 18. Standoff distance, S, is measured from the mixing stack entrance to the nozzle exit. S is positive when the nozzles are displaced out of the mixing stack and negative when into the mixing stack. The pressure tap location is designated by x, the distance from the mixing stack throat, positive toward the mixing stack exit and negative toward the stack entrance.

The momentum correction factor K_m is a measure of the completeness of mixing and provides the basis for evaluating this aspect of eductor performance. The momentum correction factor is evaluated at the exit of the mixing stack by means of two velocity traverses and the definition given in equation (4). Velocity profiles at the mixing stack exit were measured using a pitot-static tube. Since it was impractical to obtain a three-dimensional plot of velocities at the exit plane of the mixing stack, advantage was taken of the symmetry of the velocity surface resulting from the

arrangement of the primary nozzles, and only two traverses were made. The first traverse passes directly over the primary nozzles and records the peak velocities while the second traverse passes between the nozzles thus measuring the minimum velocities at the mixing stack exit. An average velocity at the mixing stack exit is obtained by integrating the velocity distribution over the mixing stack area to obtain an integrated volumetric flow rate which, when divided by the mixing stack cross sectional area, yields the average velocity. Appendix B outlines the procedure for calculating the momentum correction factor.

VI. DISCUSSION OF EXPERIMENTAL RESULTS

Eductor performance, as described earlier, considers two things, the amount of secondary air induced into the system and the degree of mixing of primary and secondary flows within the mixing stacks. For eductor systems designed to cool the exhaust gas from a gas turbine powered ship, a high pumping rate is desirable since this results in a low average mixing stack exit temperature. The degree of mixing which occurs within the mixing stack determines how closely the local values approach this average. To evaluate the total performance of an eductor both pumping and mixing must be considered. Data obtained from tests on different configuration eductors provides a means of evaluating pumping and mixing as they are affected by the geometric parameters. The parameters varied in this investigation were flow rate, length of mixing stack, distance from nozzle exit to mixing stack entrance and entrance geometry. The effect of these parameters on pumping and mixing was individually determined and from these results the effect of a specific parameter on the total performance of the eductor was evaluated. Table I summarizes the results of the individual analyses.

From plots of $\Delta P^*/T^*$ with $W^*T^{*0.44}$ for the experimental data, the value of the pumping coefficient corresponding to the open operating condition was determined. These values are tabulated in Table II.

By definition, the performance of an eductor is dependent on the completeness of mixing of the primary and secondary air streams as well as on pumping. Two measures of mixing were used in this analysis. The momentum correction factor, K_m, is a measure of the completeness of mixing and is affected by the geometric parameters tested. It therefore provides a basis for evaluating mixing as an aspect of eductor performance. The peak velocities can be related to peak temperatures and is therefore of interest when considering the ultimate use of these eductor systems. The ratio of peak velocity to average velocity was also used as a basis for evaluating mixing. The momentum correction factors and peak to average velocities are tabulated in Table III. The values presented in Table III are for a primary flow with an uptake Mach number of 0.064. Values obtained for other flow rates were approximately the same.

Another quantity measured which can be related to the completeness of mixing was the axial static pressure distribution. As mixing occurs along the mixing stack, the decrease in momentum of the air is evidenced as a pressure rise. When the non-dimensional static pressure is plotted with distance along the stack, the rate of momentum exchange is evidenced by the slope of the curve. A steep gradient represents an area of rapid momentum transfer. For optimum mixing the curve should approach atmospheric pressure tangentially at the mixing stack exit. The axial static pressure varied with angular position relative to the primary

flow nozzles. This variation gave rise to a maximum and a minimum pressure drop, corresponding to position A and B respectively. The location of these positions is shown on Figure 19. The mixing stack with the pressure taps fixed, as described previously, was rotated a full 360° with pressure readings made at 45 intervals. The results, presented in Table IV and shown on Figure 20; show there is symmetry between the maximum and minimum positions.

To verify that there is a uniform velocity profile at the primary nozzle exit a velocity traverse was made across each nozzle as shown in Figure 21. The results are presented in Table V and shown on Figure 22, indicate the flow exiting from each nozzle is fully developed.

In preparing the performance plots, $\Delta P^*/T^*$ versus W [illegible]$*^{0.44}$, a slight amount of data scatter is encountered as the open to the environment condition is approached. This scatter is attributed to the difficulty in measuring the very small pressure differentials, on the order of 0.254 cm (0.10 inch) of water and less, required for calculation of these last few points. Consequently slightly lesser importance was given these scattered points when determining the characteristic curve used in locating an eductor's pumping coefficient.

The uncertainties in the pumping coefficient (1.4%) and the pressure coefficient (1.9%) are tabulated in Appendix C. For some of the parameter variations to be discussed, changes in the pumping coefficient are within its uncertainty bounds.

Caution should therefore be exercised when using these changes for other than to indicate a trend. An uncertainty analysis of the momentum correction factor was not attempted because of the approximations inherent in its development. It is recognized that the uncertainty in the momentum correction factor is likely to exceed its changes. Such changes are used, therefore, as indications of trends only.

Table VI through Table XIII are the performance and velocity results from each configuration and flow rate tested. They are included here in the interest of completeness. Figures 40 through 43, which are plots of the $\Delta P^*/T^*$ versus $W^*T^{*0.44}$ from which the pumping coefficient for that geometry eductor system was determined, are also included for completeness.

The following discussion addresses the individual parameter variations and their effect on eductor performance and in so doing references the results of tests performed on each geometry.

A. UPTAKE MACH NUMBER

The effect of the uptake Mach number on eductor performance was evaluated by varying the uptake Mach number from 0.034 to 0.064. These Mach numbers were chosen because they correspond to the uptake Mach number on an existing eductor system, and were the values selected by Ellin [1].

The effect of Mach number on the pumping coefficient is evidenced in Table II and Figures 23 and 24. As can be

seen on Figures 23 and 24 the Mach number affects the slope of the pumping characteristic curves only very slightly. The intercept of the pumping characteristic curves are essentially unchanged by varying the Mach number as shown in Table II.

The momentum correction factor and velocity peaks are also essentially unaffected by Mach number variations as illustrated on Figures 25 and 26. The plots on Figures 25 and 26 show the Mach number only affects the velocity profiles by less than 1.0%.

The non-dimensional axial static pressure distribution for the mixing stack is affected by Mach number only at the entrance regions of the mixing stack. For the first diameter of length the value of PMS* is lower for the higher Mach numbers giving a steeper slope and therefore a higher momentum exchange than the lower Mach numbers. The effect of Mach number after the first diameter of length is negligible.

The magnitude of the uptake Mach number was shown to have essentially no effect on the non-dimensional values used in this investigation. Two Mach numbers were used for all pumping coefficient and mixing stack pressure distributions but only one for the majority of the velocity profiles. All figures used in the following discussion will only present the curves corresponding to a Mach number of 0.064 as the pressures for this flow rate were easier to measure. Results from both Mach numbers are presented in the Tables VI to

XIII. This independence on uptake Mach number was also observed by Ellin [1] and Harrell [10].

B. LENGTH OF MIXING STACK

The mixing stack length was varied from L/D = 2 to L/D = 3. These lengths were chosen because they represent a bound on practical lengths for application on gas turbine powered ships.

The pumping coefficient for the two lengths tested are tabulated in Table II. Figure 29 plots the pumping coefficient versus standoff for each L/D for the configuration without a transition. At each S/D up to 0.5, the pumping coefficient for L/D = 3 is higher than the L/D = 2. Above S/D = 0.5, the difference gets smaller and at S/D of 1.0 there is no significant difference in pumping coefficient. Along with the data from this investigation, data taken by Harrell [10] is plotted. The data from Harrell is within 5.0% of the results of this investigation. The trend of increasing pumping coefficient with increasing L/D for standoffs less than 0.75 was observed in both investigations. Figure 30 shows that with a transition on the mixing stack the overall length of the mixing stack has a more important effect on the pumping coefficient. The difference between L/D of 3 and L/D of 2 again lessens as the standoff increases.

Table II and Figures 31 and 32 show the effect of L/D on the momentum correction factor and the peak velocity. Figure 31 shows that the momentum correction factor, K_m,

is lower for L/D of 3 than L/D of 2 whether the transition is on or off. The peak velocities always are lower for L/D of 3 again regardless of transition or S/D.

The non-dimensional pressure distribution, PMS*, plots illustrated in Figures 33 and 34 show that the slope of the curves at the mixing stack exit is lower for L/D of 3 than L/D of 2 while the initial slope at the entrance is greater. This indicates there was a greater momentum exchange, more rapid mixing, for L/D of 3 and thus a more complete mixing at the exit reflected by a shallower slope of the curve. Figure 33 is a plot of PMS* versus x/D for S/D = 0.25 without a transition and Figure 34 is for S/D = 0.25 with a transition. The same trend of more complete mixing is evidenced in both figures. Plots of other standoffs show the same trend in this investigation as well as the research of Harrell [10].

C. DISTANCE BETWEEN THE NOZZLE EXIT AND MIXING STACK ENTRANCE

The distance between the primary flow nozzle exit and the mixing stack entrance, standoff distance, had a pronounced effect on the performance of the eductor system. Table II and Figures 29 and 30 show the effect of varying standoff S/D on the pumping coefficient. For the no transition configuration as S/D increases the pumping coefficient increases up to a maximum value and then decreases to a constant value. With further increase of S/D the pumping coefficient falls sharply as the turbulent jet expands larger than the diameter

of the mixing stack. For the transition on configurations the performance remained fairly constant as S/D was increased for L/D = 3. For L/D = 2 the pumping increased for S/D less than 0.25 and then remained fairly constant. The optimum standoff, as reflected by the maximum pumping, appeared to be a function of L/D and entrance region geometry, both to a minor extent. From Putilov [9] the optimum S/D is also a function of the mixing stack to primary flow nozzle area ratio.

The effect of S/D on the momentum correction factor and peak to average velocities is demonstrated in Table III and Figures 31 and 32. Both the momentum correction factor and peak velocities decrease with increasing S/D indicating more complete mixing as standoff is increased.

The effect of S/D on the axial static pressure distribution is illustrated in Figure 35. The plot of PMS* versus x/D produces a curve which approaches the mixing stack exit pressure more tangentially for higher values of S/D. This indicates a more complete mixing has taken place inside the mixing stack.

D. MIXING STACK ENTRANCE GEOMETRY

Table II and Figures 36 and 37 show the effect of adding a conical transition to the mixing stack entrance. From Table II and as can be seen from Figures 36 and 37 the pumping coefficient for the stack with a transition is higher than one without for standaoff less than 0.25. At standoff equal

to 0.50 the pumping is about the same and appears to remain about equal up to a standoff of 1.0.

The effect of the transition on mixing is illustrated in Table III and Figures 31 and 32. For standoff less than 0.50 the momentum correction factor for a mixing stack with a transition is higher than for a mixing stack without a transition indicating less mixing has taken place. For standoffs equal to and greater than 0.50 the K_m appears to be the same. The mixing stack of length L/D = 3.0 shows a smaller effect from the transition than does the mixing stack with L/D = 2.0. The peak velocities indicate that the transition does promote better mixing above S/D = 0.25. More research is necessary to determine which configuration does provide better mixing.

Figures 38 and 39 show that mixing is more complete without a transition for S/D less than 0.5. In Figure 38 for a mixing stack of length L/D = 3 with the S/D = 0.0 the PMS* versus X/D curve for the mixing stack without a transition approaches atmospheric pressure more tangentially than does the curve for the mixing stack with a transition. The mixing is therefore more complete without a transition than with a transition for this standoff. The curves on Figure 39, for S/D = 0.50, approach the exit pressure with about the same slope indicating about the equal completeness of mixing as was indicated from Figures 32 and 33 and Table III.

VII. CONCLUSIONS

The objective of this investigation was to determine the effect of variation of geometric parameters on the performance of a multiple nozzle eductor system. The trends and interdependency of geometric parameters were discussed in detail in Section VI and the resulting conclusions are summarized here.

A. The effect of the uptake Mach number on the pumping coefficient and on the degree of mixing was negligible over the range of flow rates tested.

B. An improvement in pumping can be obtained with an increase in the length of the mixing stack. Additionally, a significant improvement in mixing is realized with increasing length of mixing stack.

C. Increasing the distance between the primary flow nozzles and the mixing stack gave an increase in the pumping coefficient. The limiting value for standoff was determined by the need to keep the primary flow contained within the mixing stack. The effects of increasing standoff were more pronounced with the mixing stacks without a transition than the ones with a transition. The standoff also had varying effects with the different length mixing stacks. In all cases tested mixing was enhanced by increasing the standoff distance.

D. The conical entrance transition tested gave a higher pumping coefficient for standoffs less than 0.50. Above a standoff of 0.50 the pumping coefficient for a given length mixing stack is about equal with or without an entrance transition. Mixing is better without the transition for standoffs less than 0.50. For standoffs equal to and above 0.50 the mixing appears to be about the same for a given length mixing stack with the transition on or off.

In terms of total eductor performance considering pumping and mixing the utility of an entrance transition is questionable. Based on the results of this research a mixing stack of length L/D = 3.0 with a standoff of approximately 0.50 without a transition appears to give the best performance.

VIII. RECOMMENDATIONS

In addition to providing insight into the nature of the effects of geometric parameters on eductor performance, this research also has raised questions to be solved by further research. Among the areas necessary to further the understanding of multiple nozzle eductor systems are the recommendations listed below.

A. The effect of changing the mixing stack area to primary flow area ratio was established by Ellin [1]. Experimentation would be useful to determine the effect this area ratio has on the optimum standoff.

B. The momentum correction factor as well as the peak to average velocity ratio is affected by a number of uncertainties. An investigation of the best measure of the degree of mixing would be of upmost importance to future research.

C. It is evident that the number of geometric variations of an eductor configuration is virtually unlimited. Other geometric parameters of interest for further research include the use of a converging diverging mixing stack, and varying the geometry of the nozzles with respect to inducing a swirl in the mixing stack to enhance mixing.

IX. FIGURES

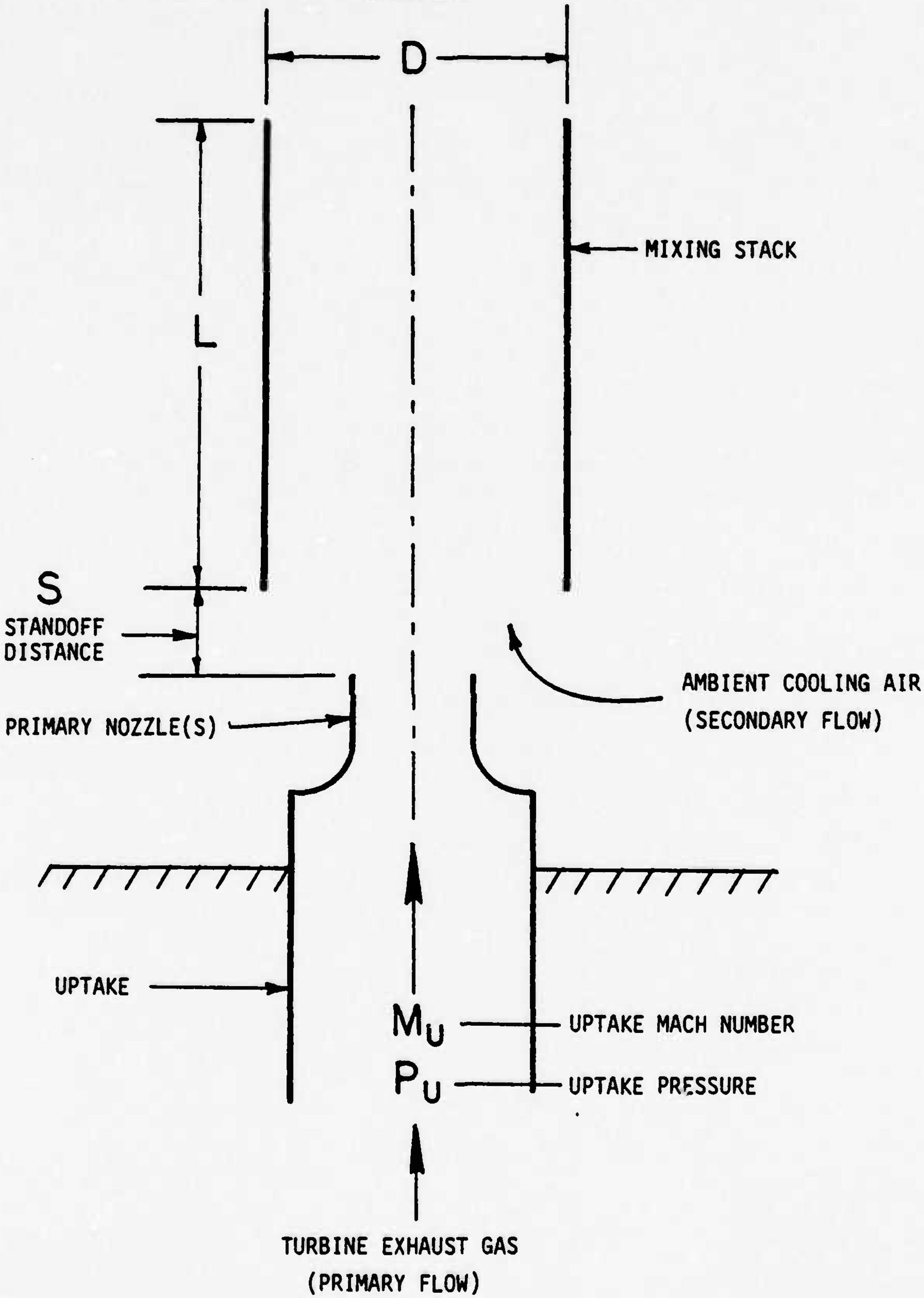


FIGURE 1. Schematic Diagram of Simple Exhaust Gas Eductor

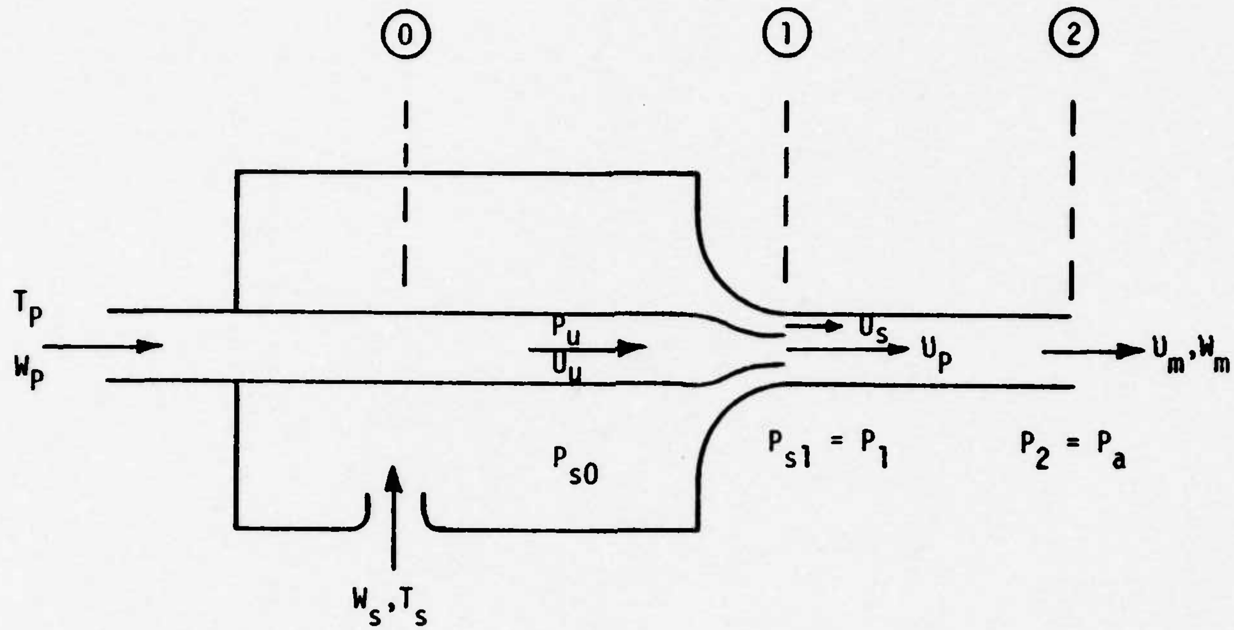
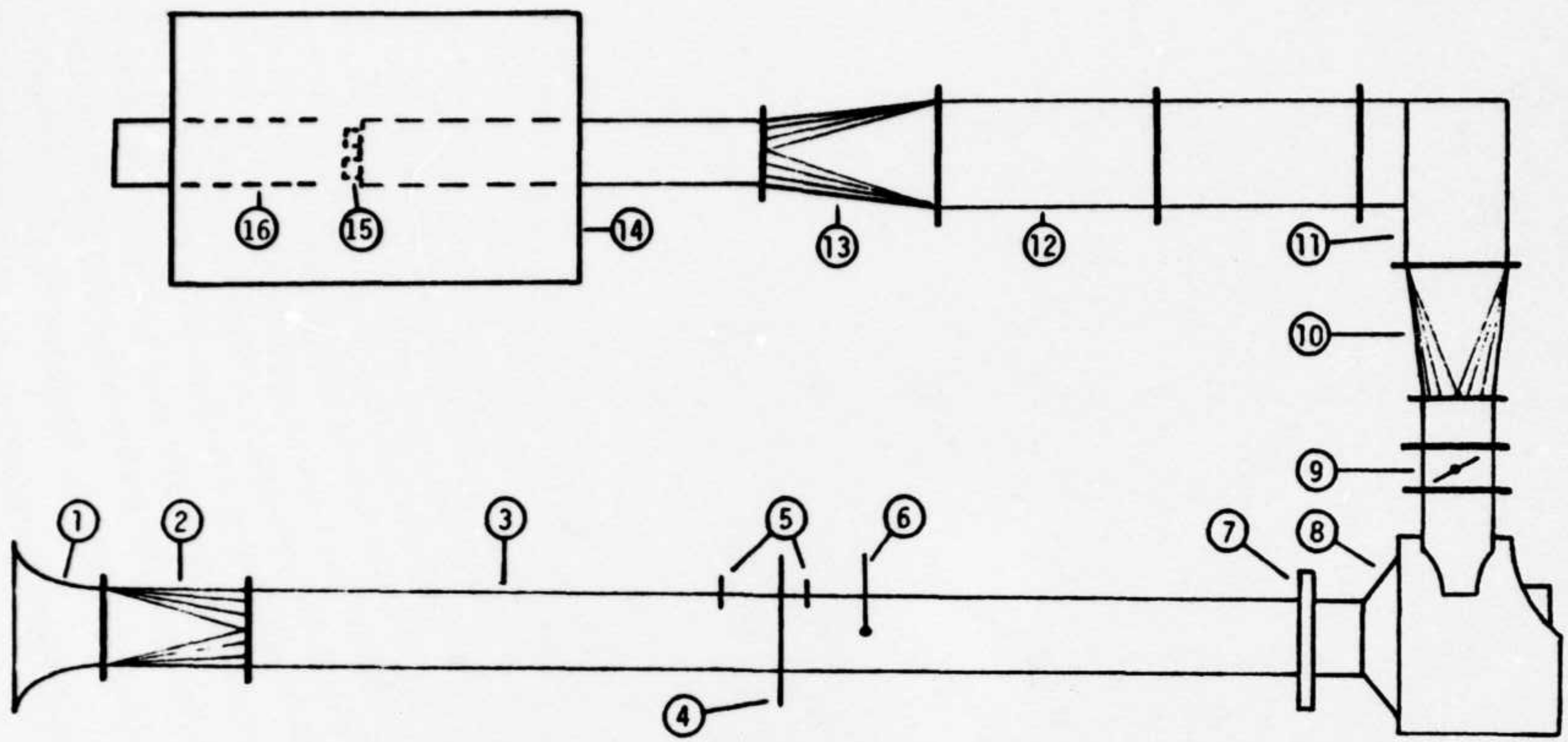


FIGURE 2. Simple Single Nozzle Eductor System.



1	Entrance Reducer	5	Piezometer Ring	9	Butterfly Valve	13	Transition
2	Transition	6	Thermocouple	10	Transition	14	Secondary Air Plenum
3	Circular Duct	7	Variable Orifice	11	Elbows	15	Primary Flow Nozzles
4	Orifice Plate	8	Compressor	12	Square Duct	16	Mixing Stack

FIGURE 3. Eductor Test Facility.

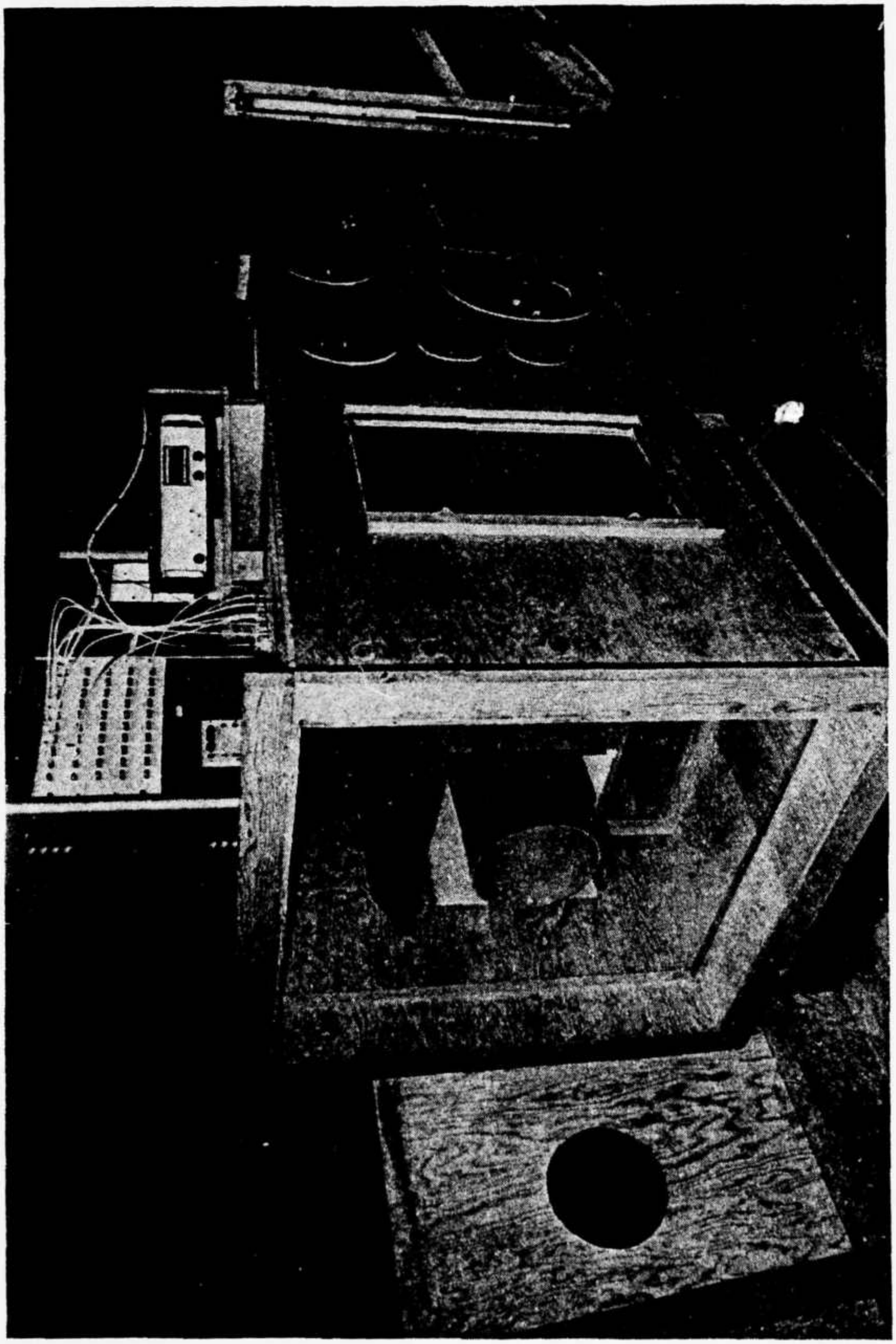


FIGURE 4. Secondary Air Plenum

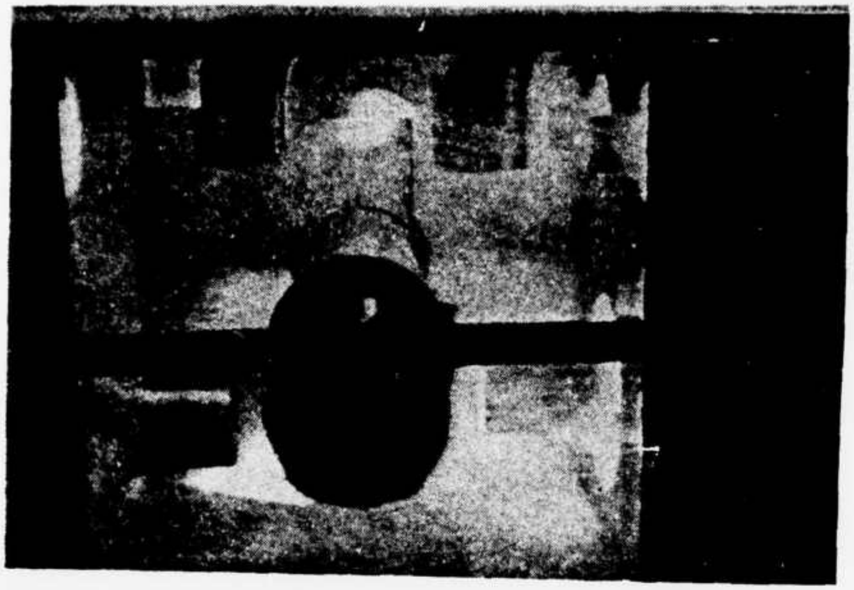


FIGURE 5. Interior of Secondary Air Plenum Showing Screens and Flow Nozzles

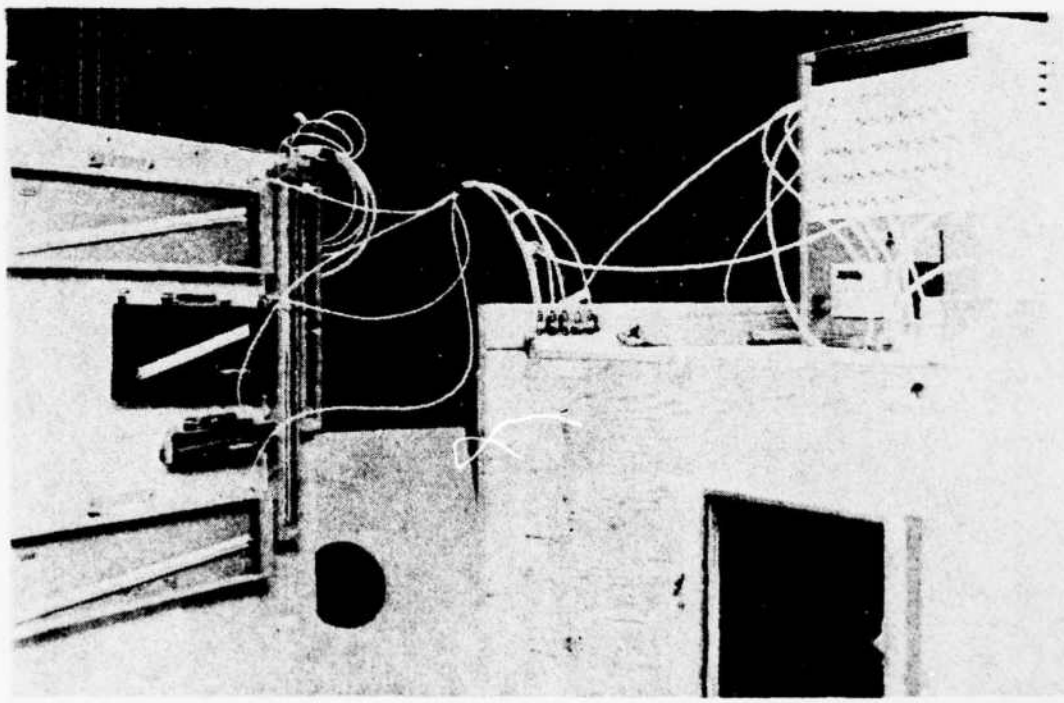


FIGURE 6. Scanivalve, Valve Manifold, and Manometer Bank with Secondary Air Plenum

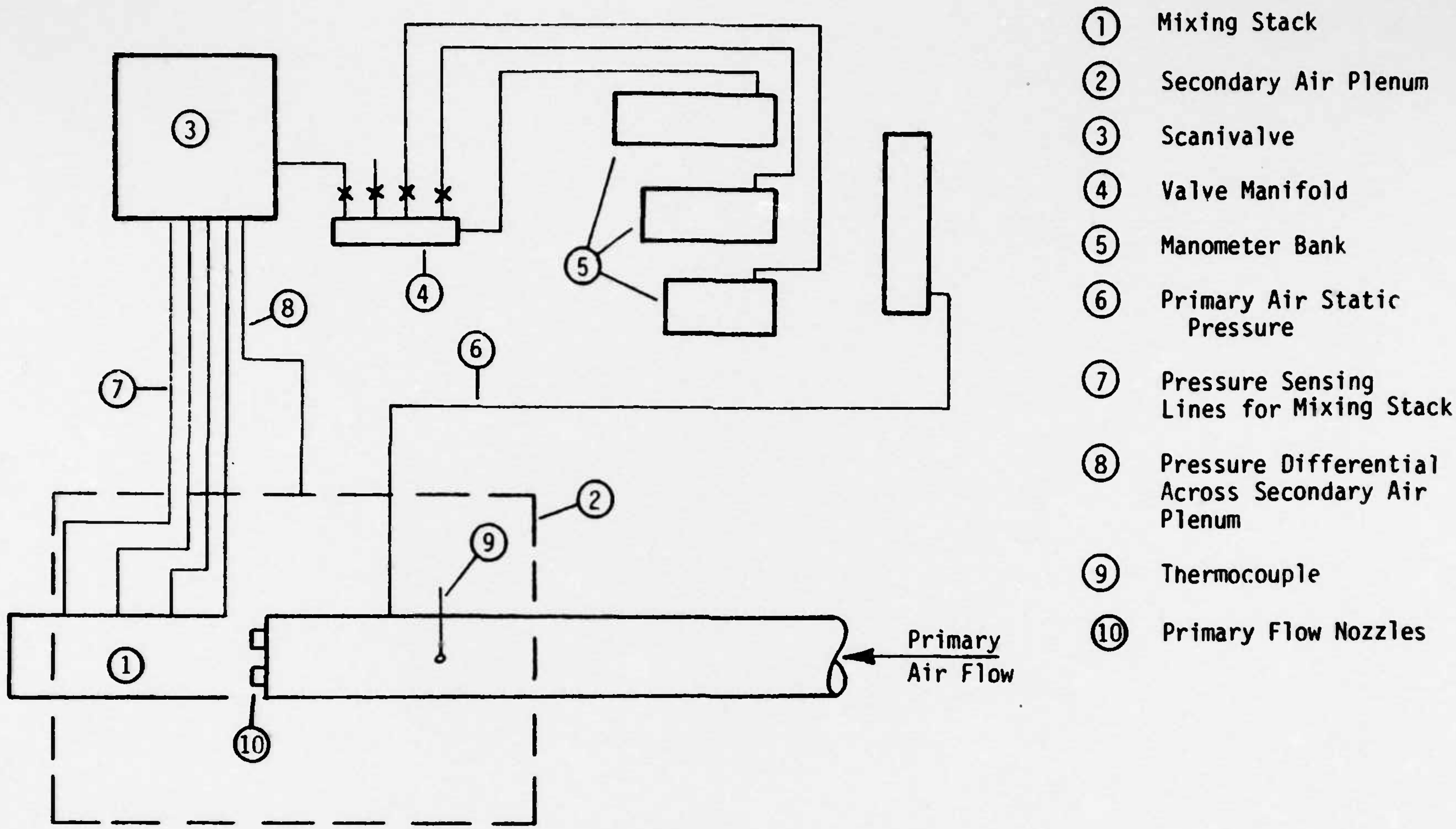


FIGURE 7. Schematic of Instrumentation Hookup for Model and Secondary Air Plenum.

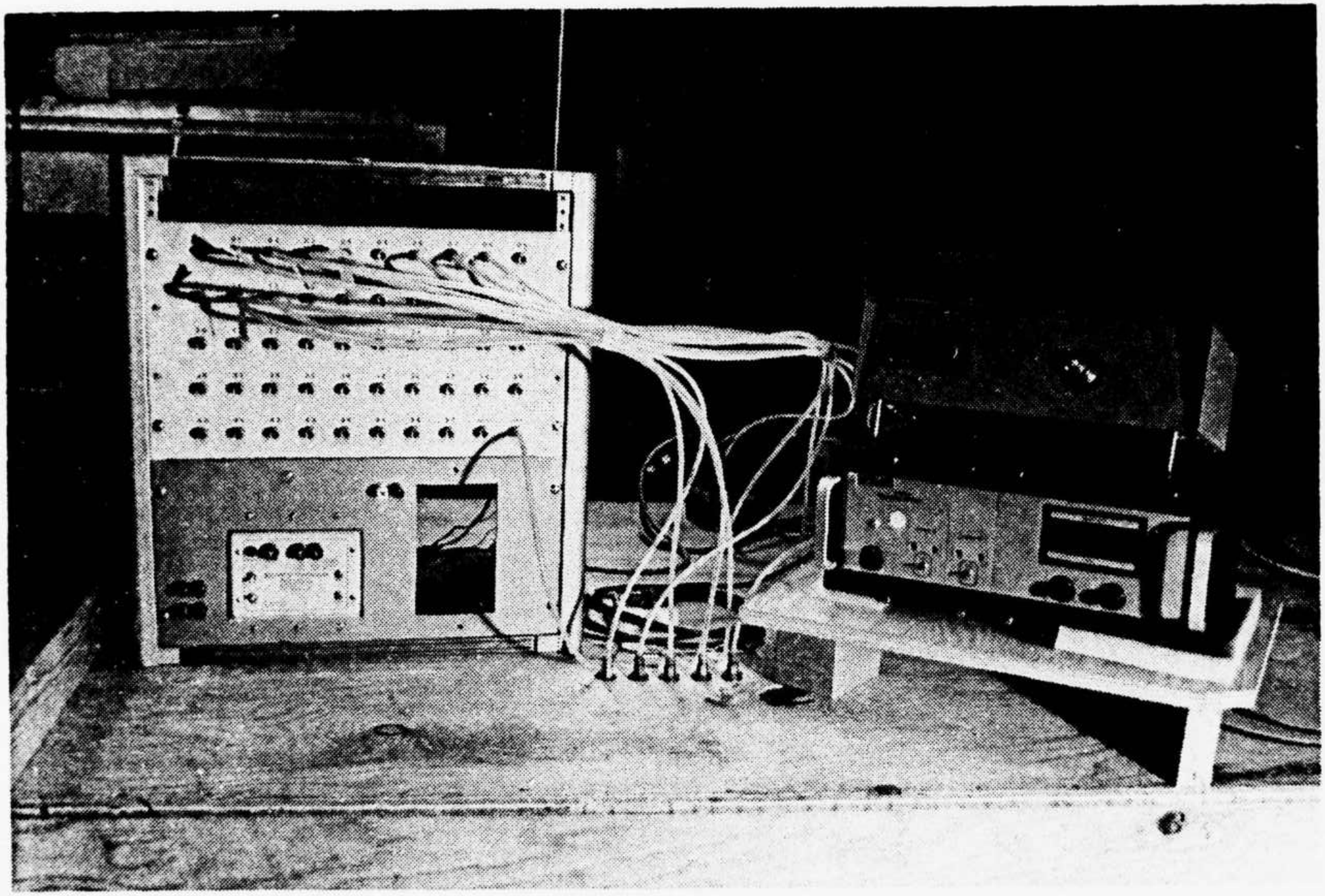


FIGURE 8. Instrumentation for Mixing Stack and Secondary Air Plenum

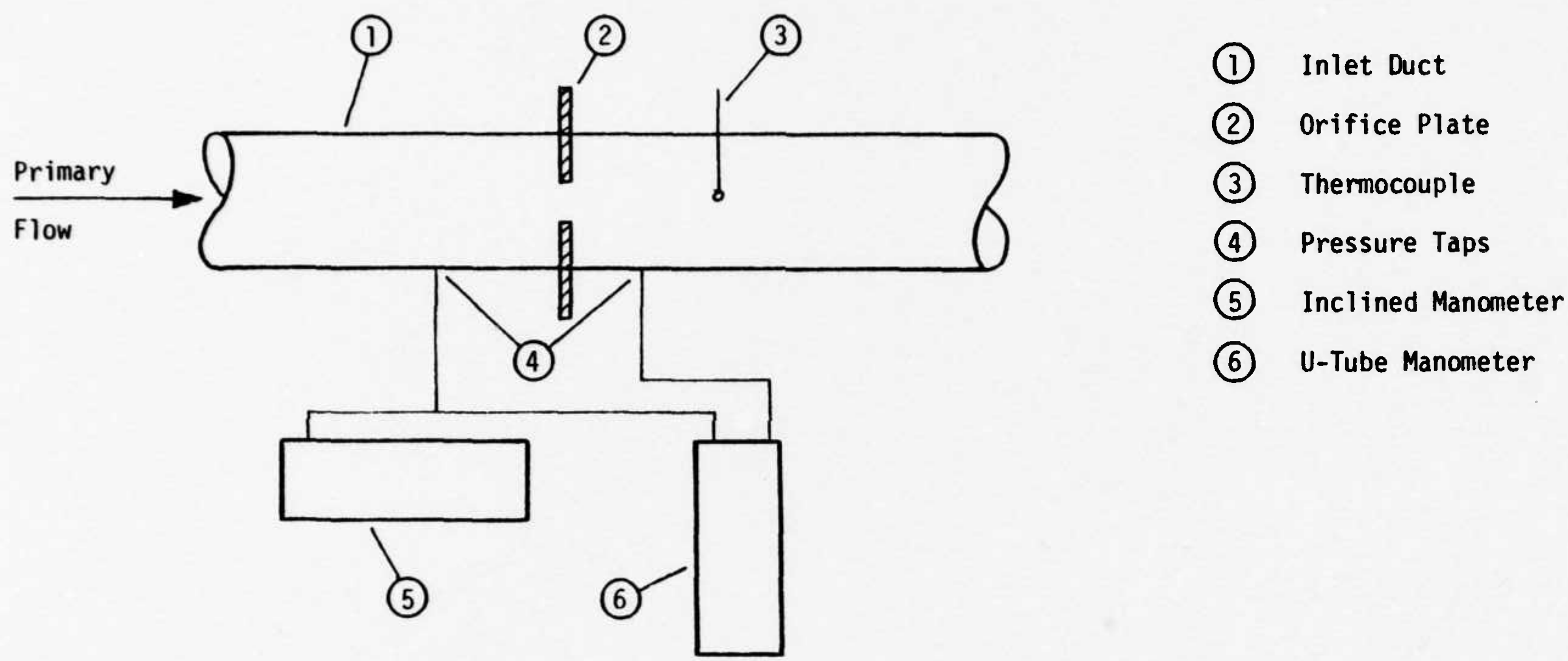


FIGURE 9. Schematic of Instrumentation Hookup for Primary Air Flow Measurement.

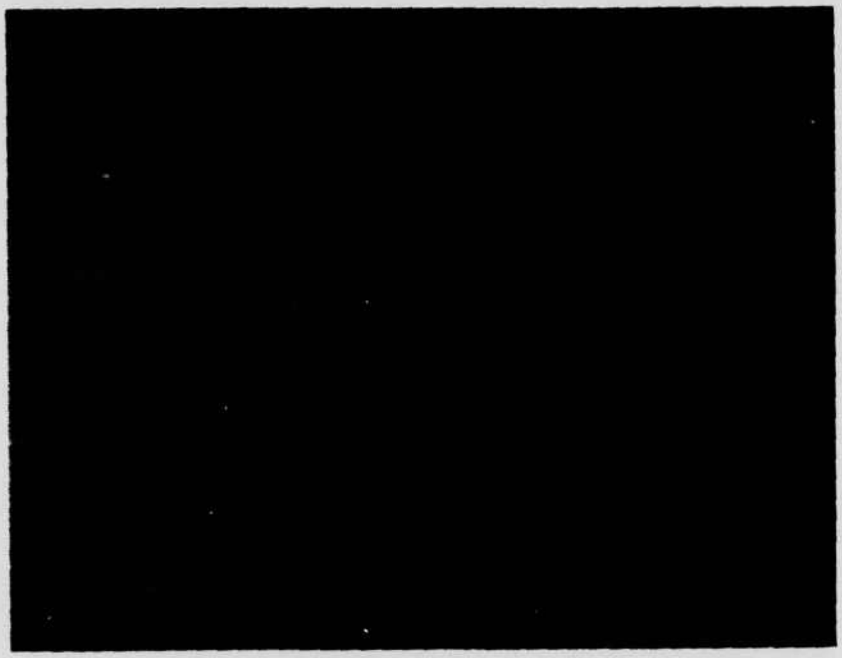


FIGURE 10. Primary Flow Nozzles Used in This Investigation

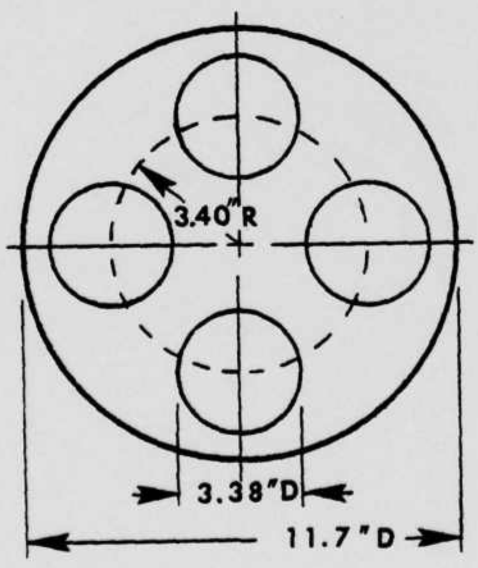


FIGURE 11. Layout of Primary Nozzles

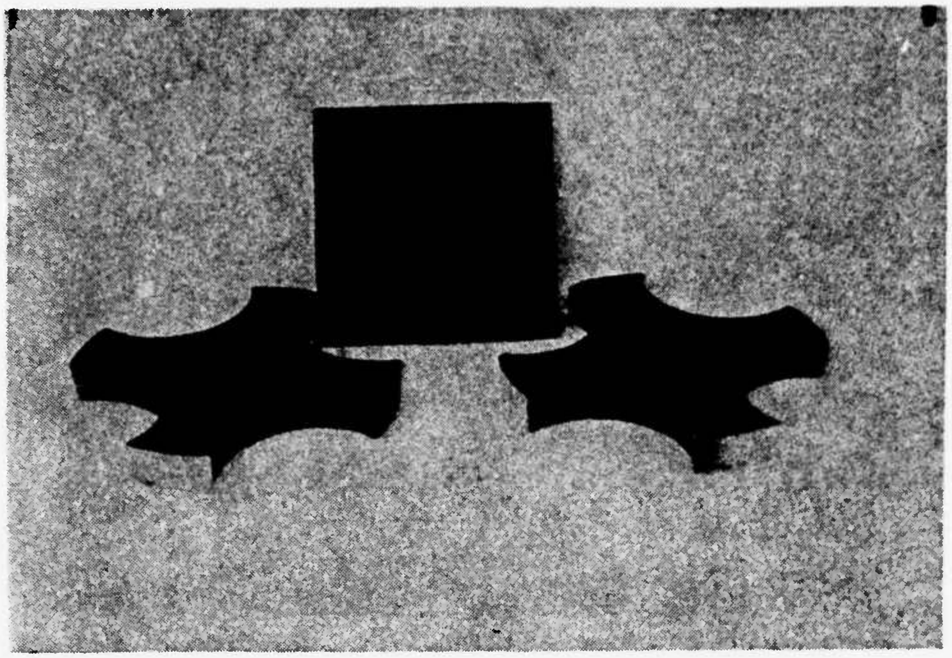


FIGURE 13. Alignment Plugs for Mixing Stack and Primary Nozzle

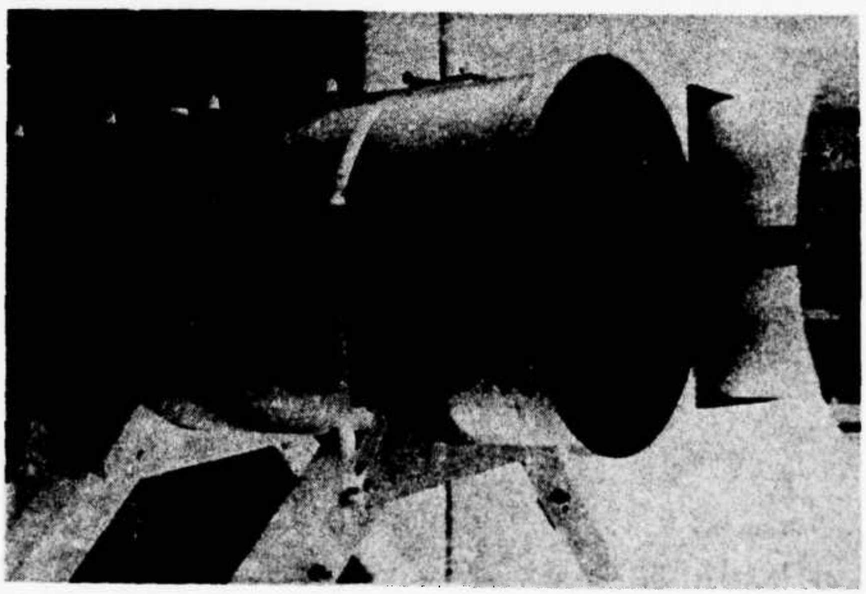


FIGURE 14. Mixing Stack Alignment with Primary Air Nozzles in Secondary Air Plenum

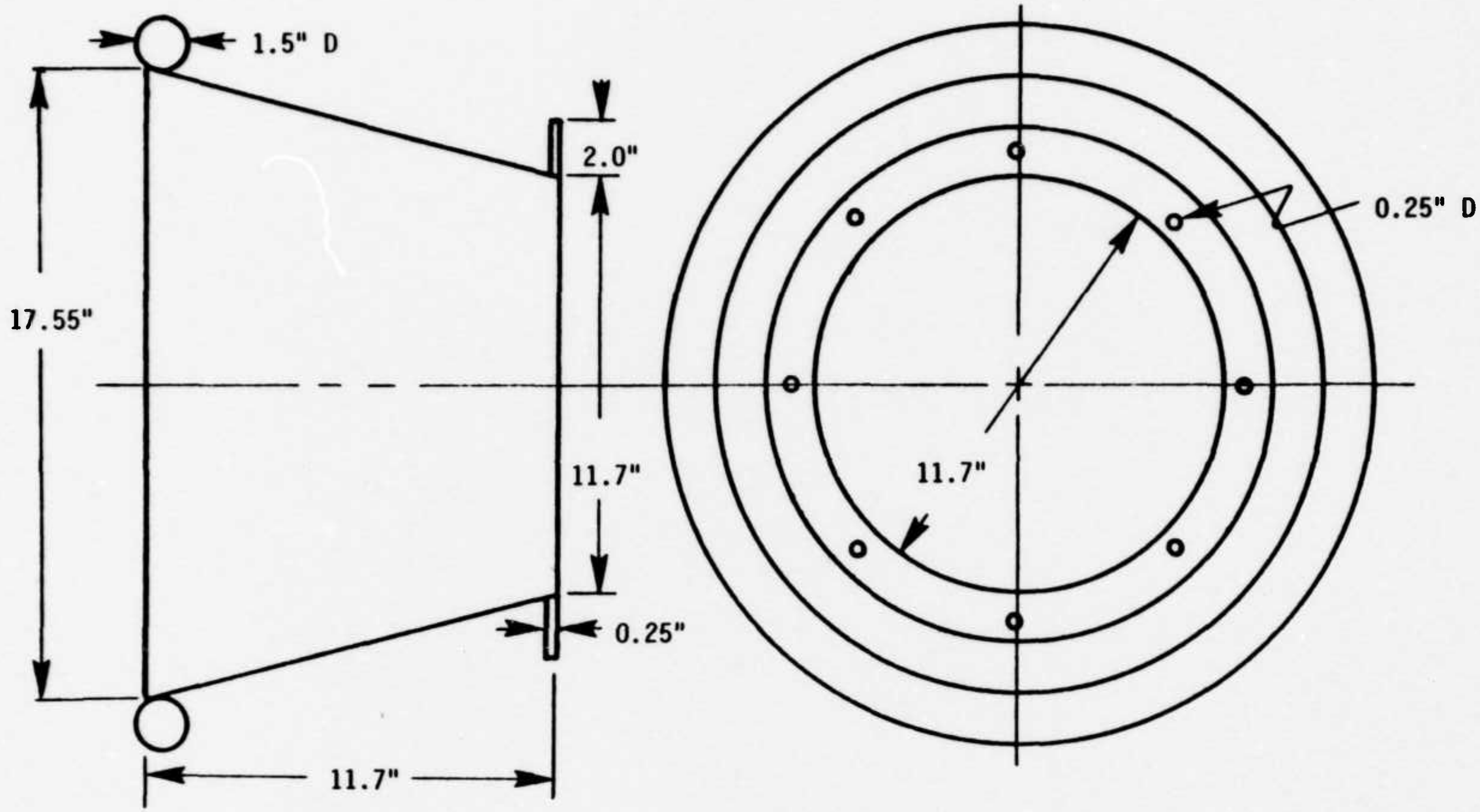


FIGURE 15. LAYOUT OF CONICAL TRANSITION

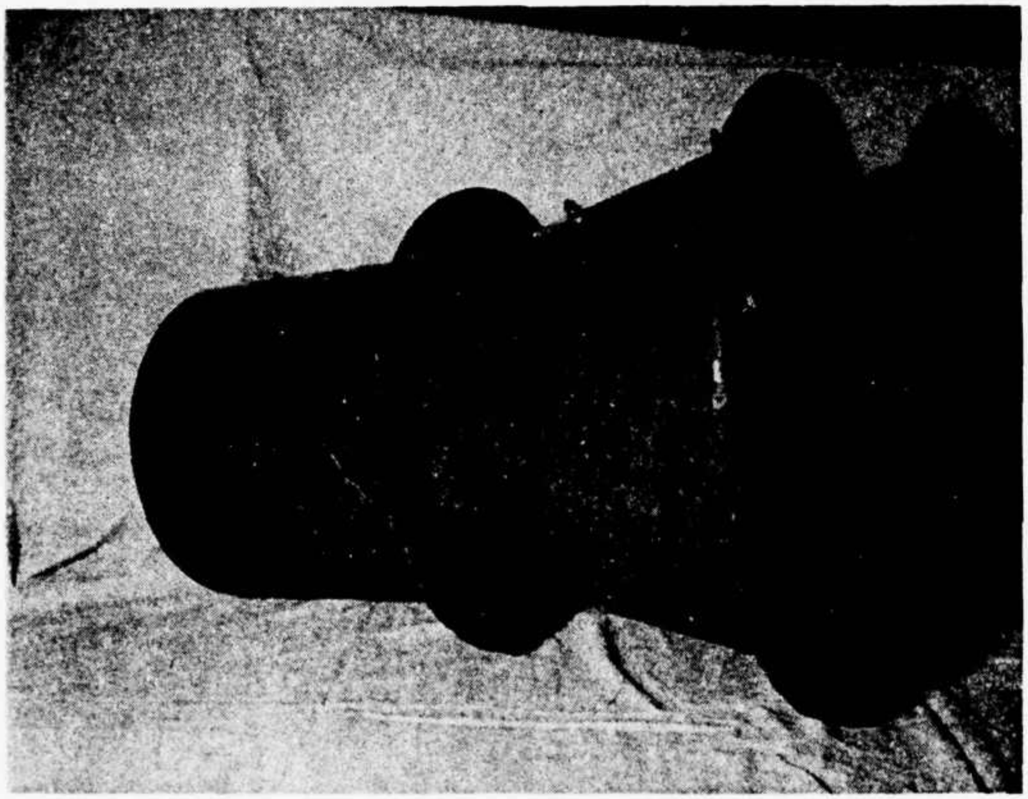


FIGURE 16. Conical Transition Attached to Mixing Stack

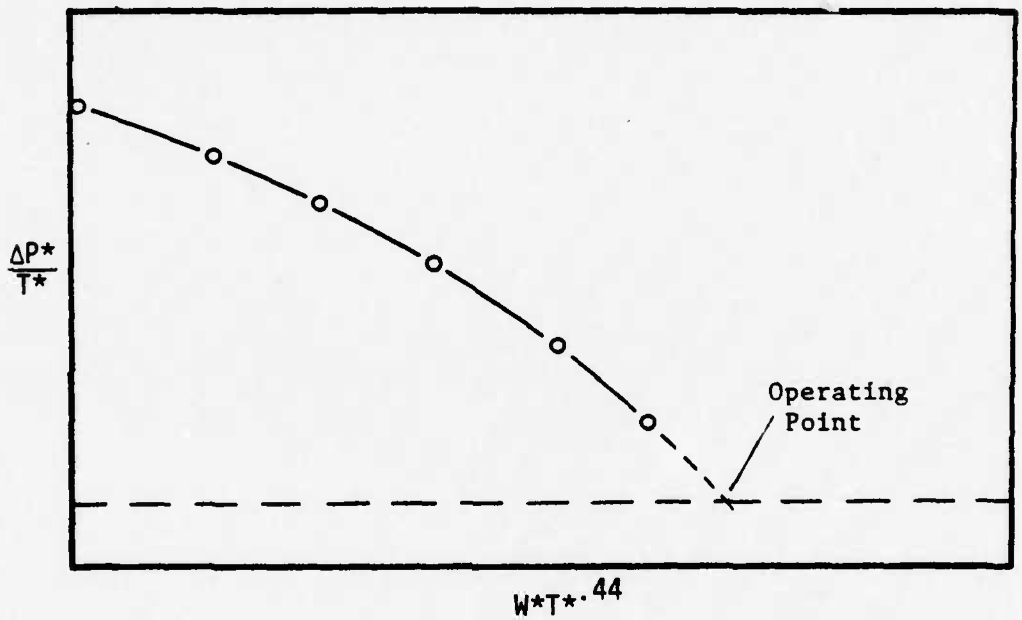


FIGURE 17. Illustrative Plot of the Experimental Data Correlation in Equation (14).

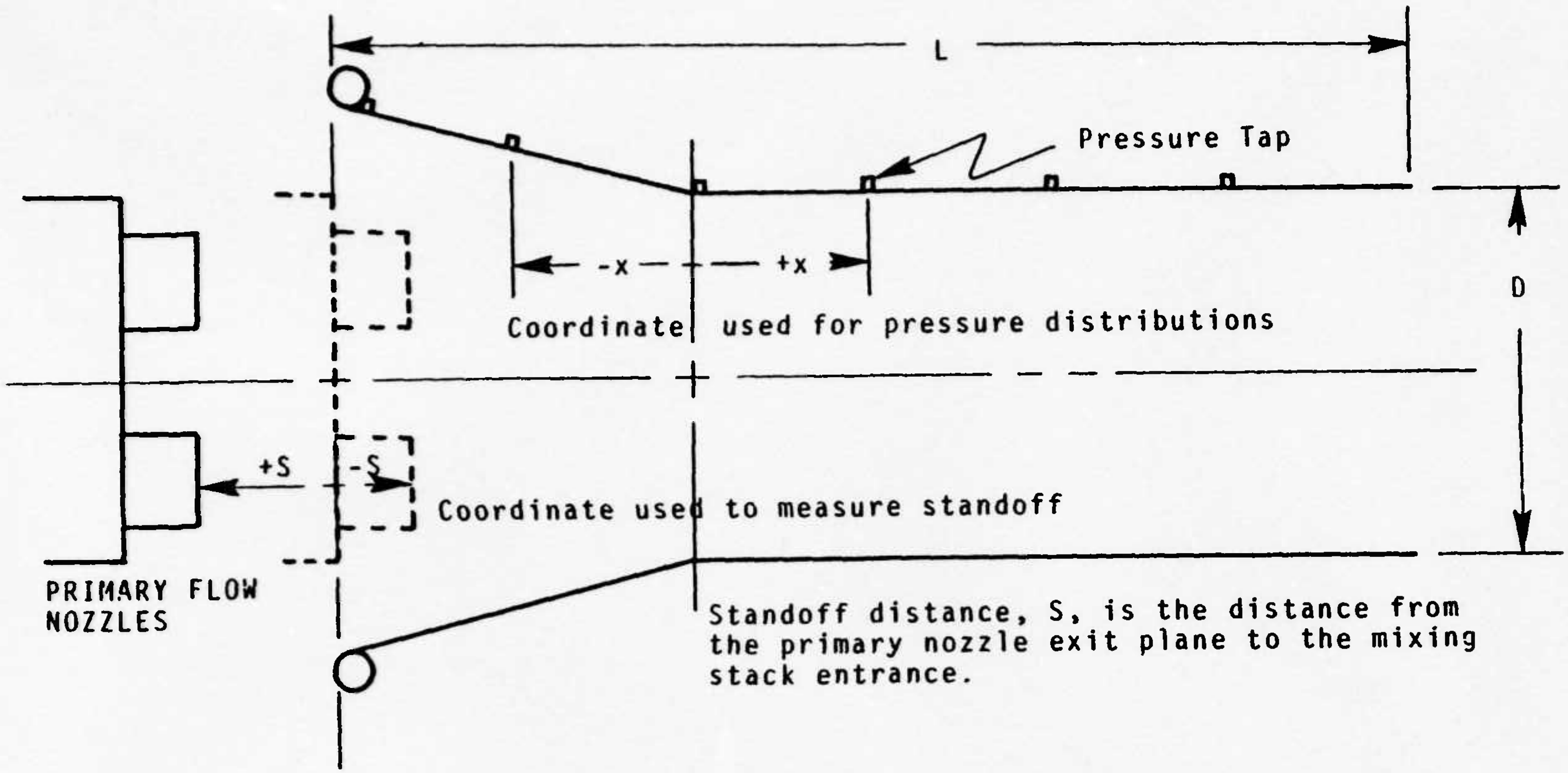


FIGURE 18. Coordinate System Used for Eductor System

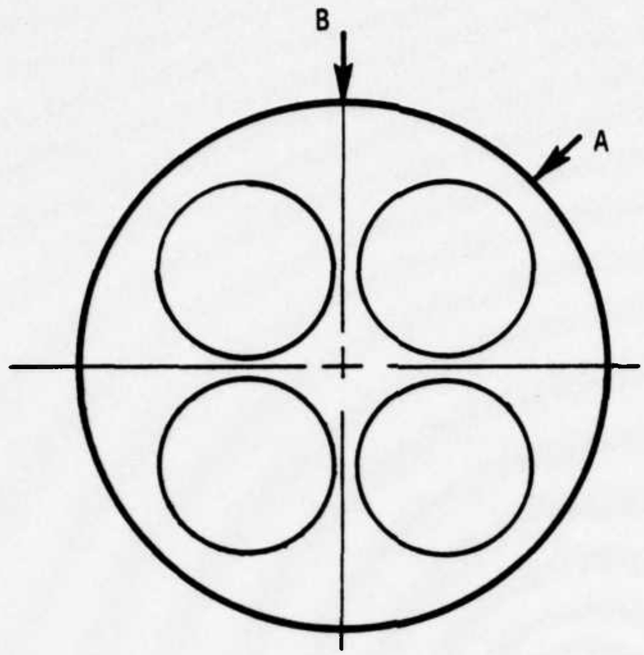


FIGURE 19. Orientation of Static Pressure Taps Relative To Primary Flow Nozzles.

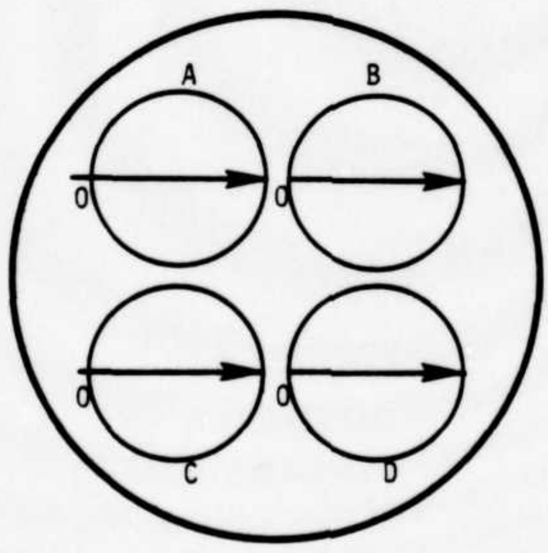


FIGURE 21. Coordinate System Used For Table V (Nozzle Exit Velocities).

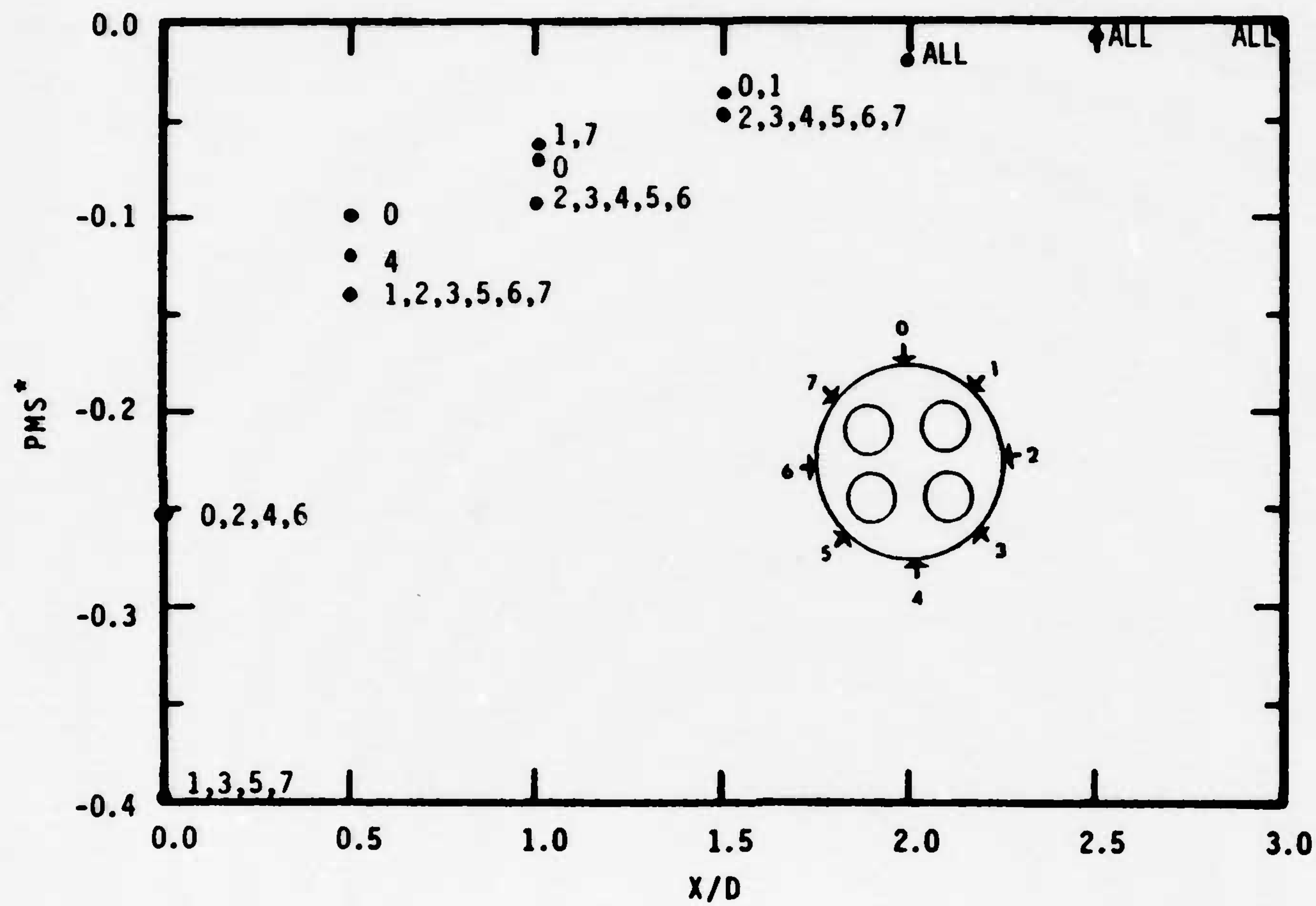
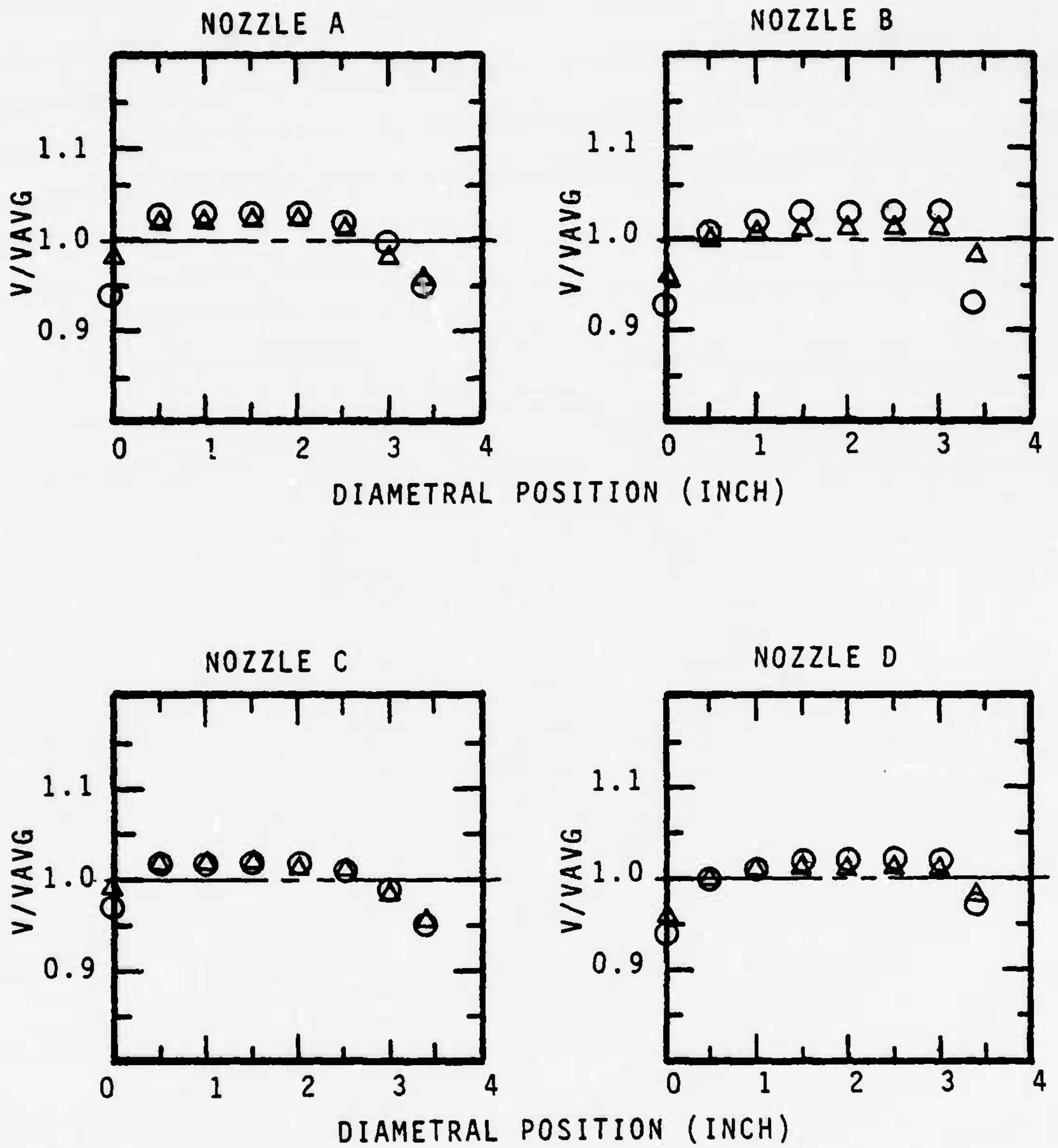


FIGURE 20. Circumferential Pressure Distribution



L/D= 3 Without Transition

S/D= 0.5

○ UPT Mach No.= 0.034

△ UPT Mach No.= 0.064

FIGURE 22. Primary Nozzle Exit Velocities

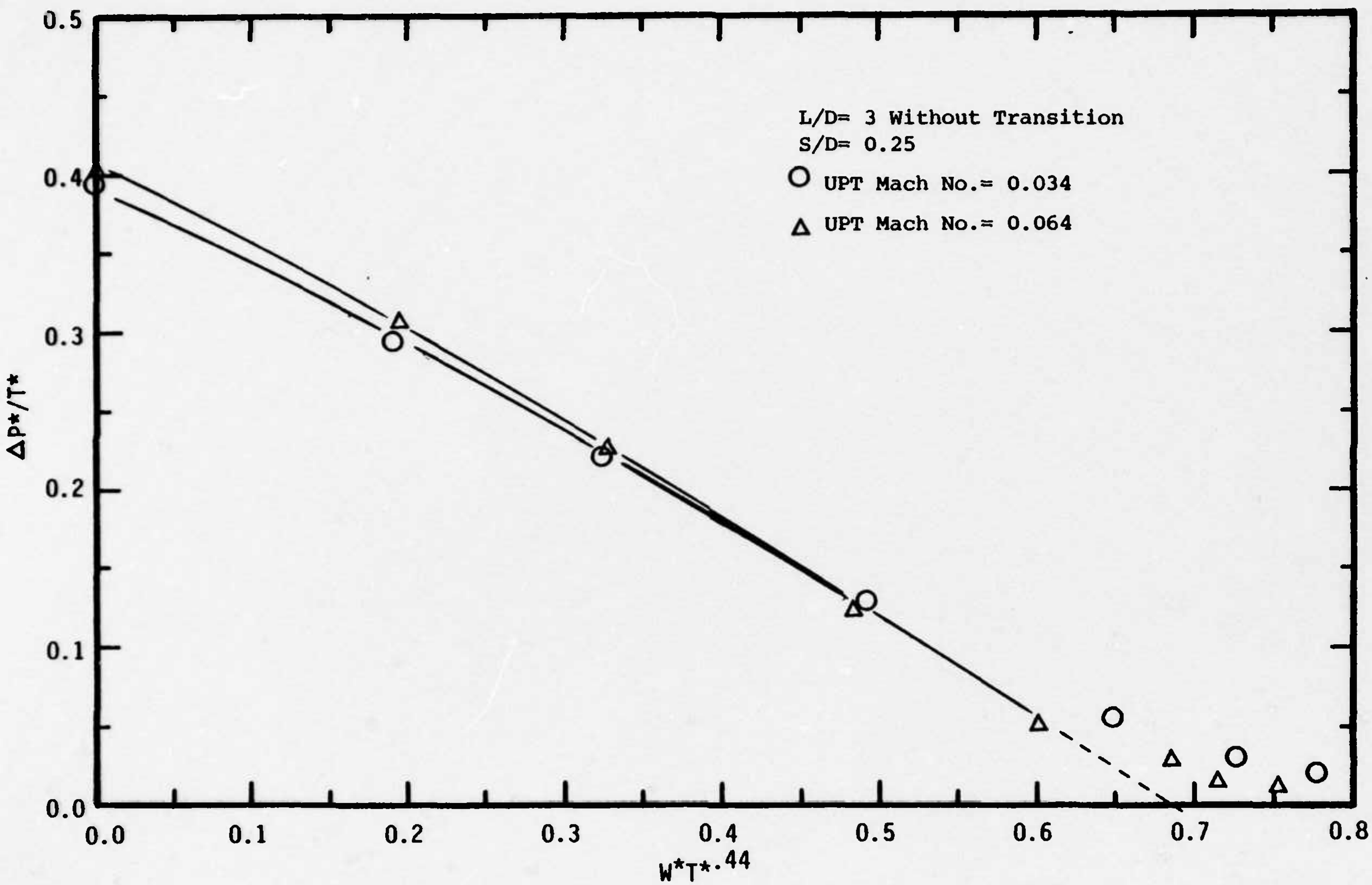


FIGURE 23. Effect of Variation of Mach Number on Pumping Characteristic Curves Without a Conical Transition

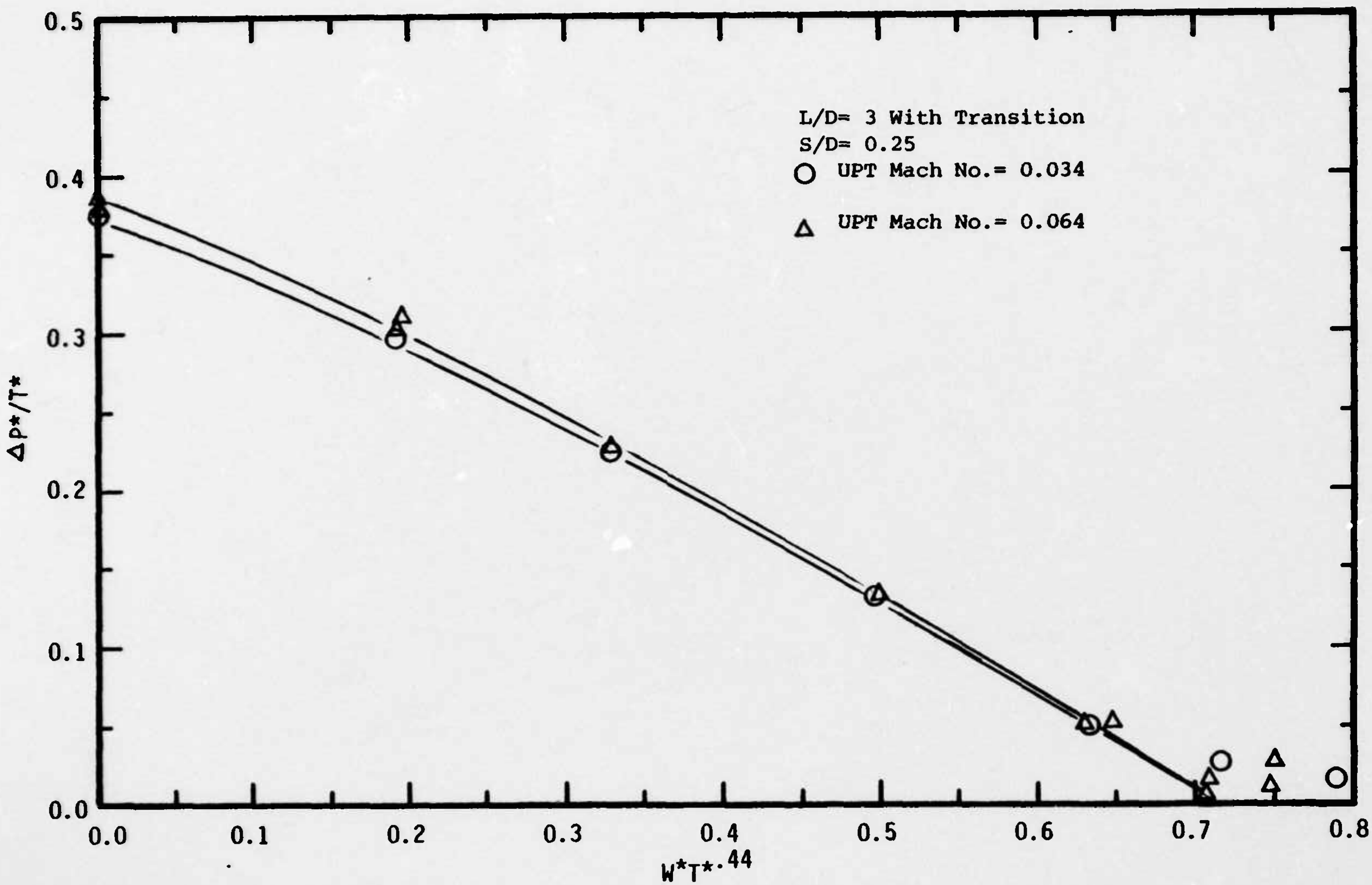


FIGURE 24. Effect of Variation of Mach Number on Pumping Characteristic Curves With a Conical Transition

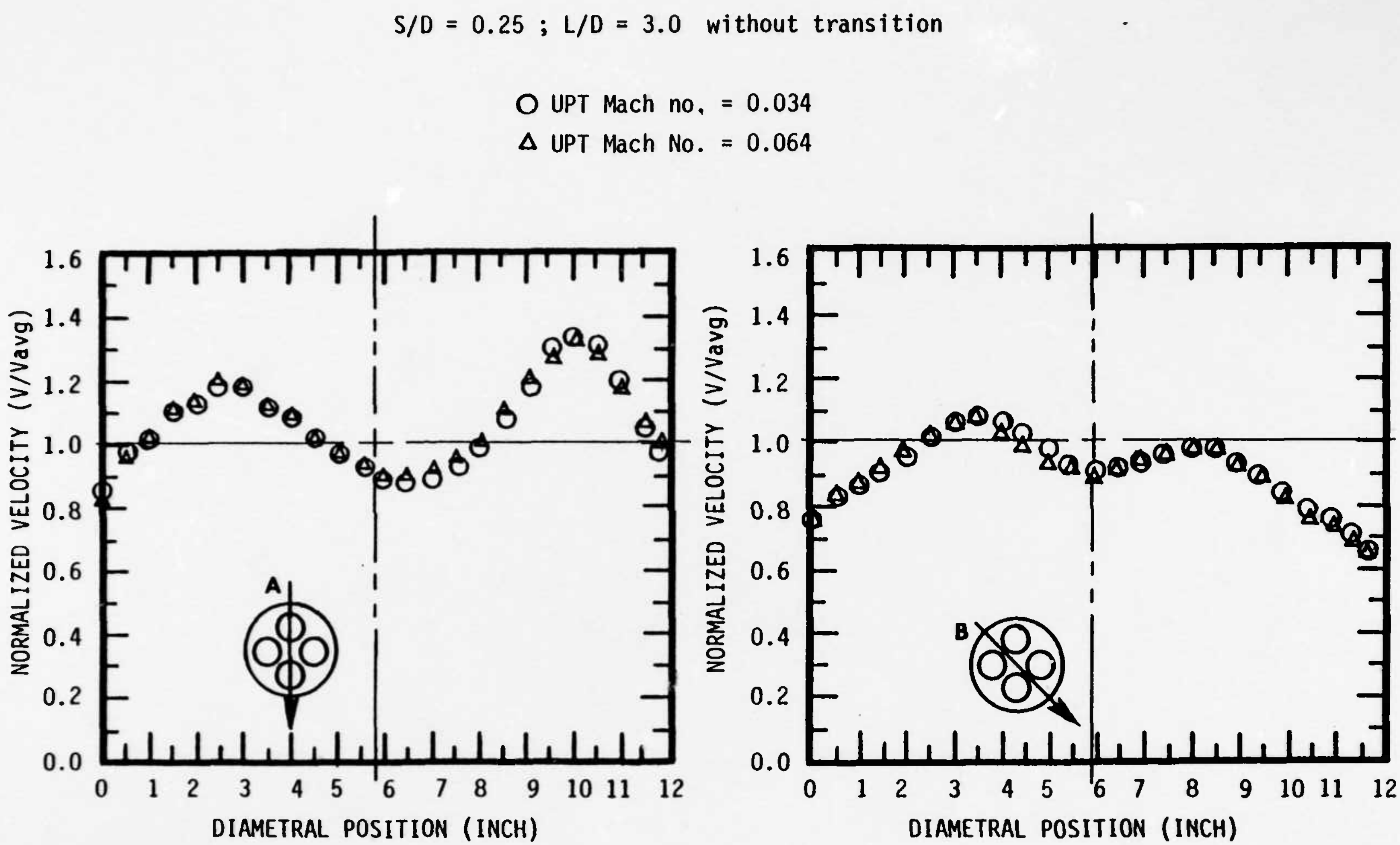


FIGURE 25. Effect of Variation of Mach Number on Velocity Profiles Without a Conical Transition

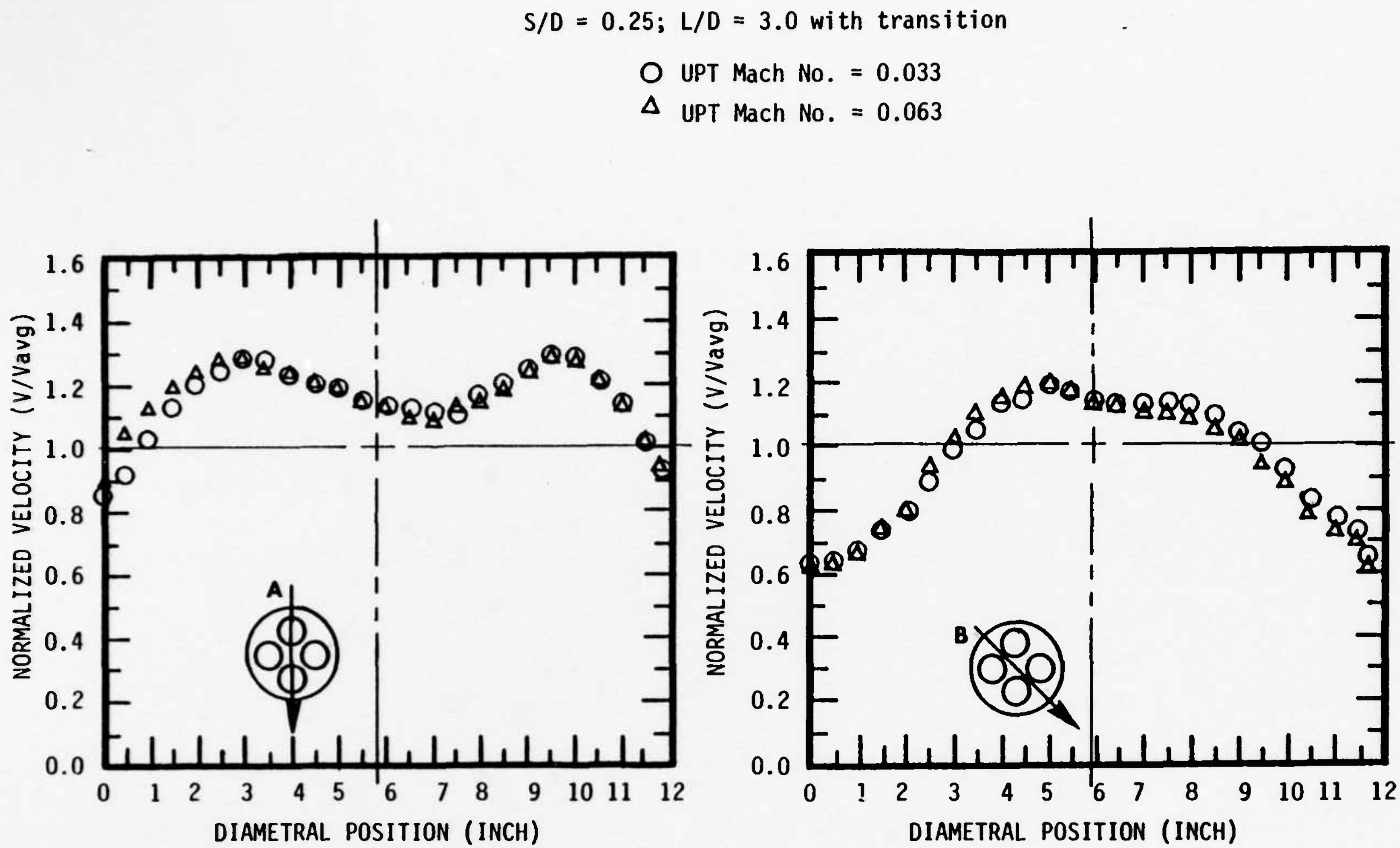


FIGURE 26. Effect of Variation of Mach Number on Velocity Profiles with a Conical Transition

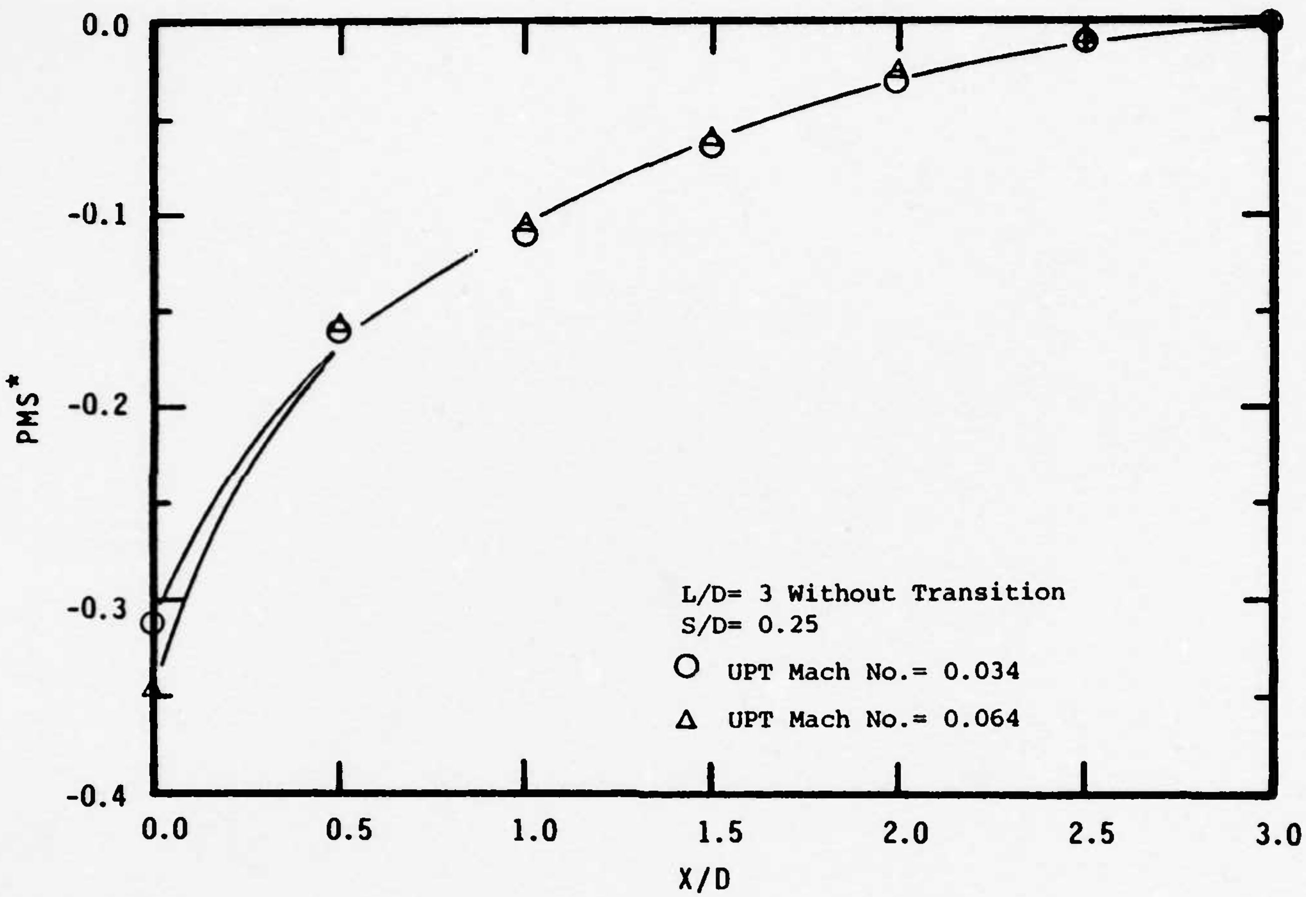


FIGURE 27. Effect of Variation of Mach Number on Mixing Stack Pressure Distributions Without a Conical Transition

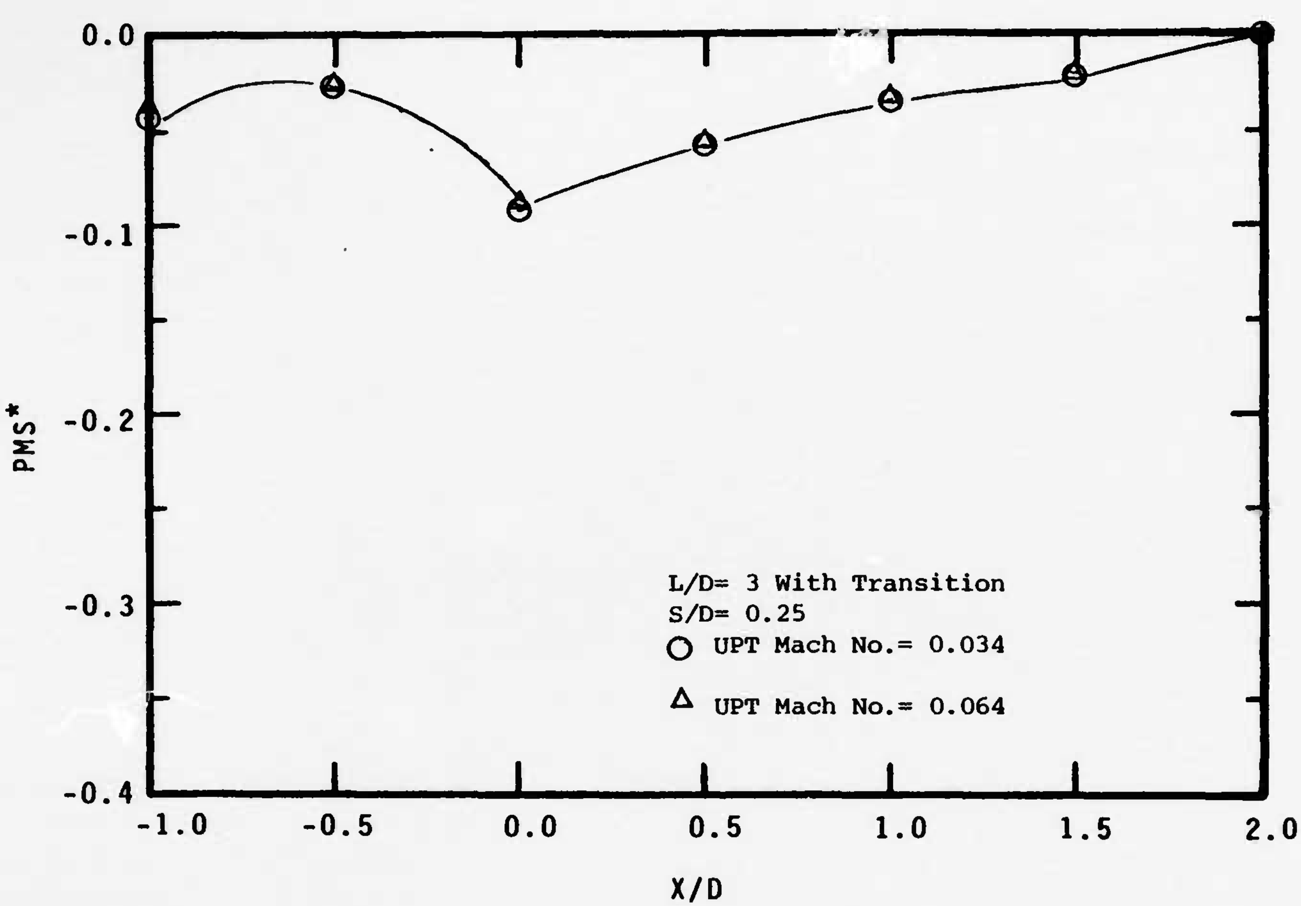


FIGURE 28. Effect of Variation of Mach Number on Mixing Stack Pressure Distribution With a Conical Transition

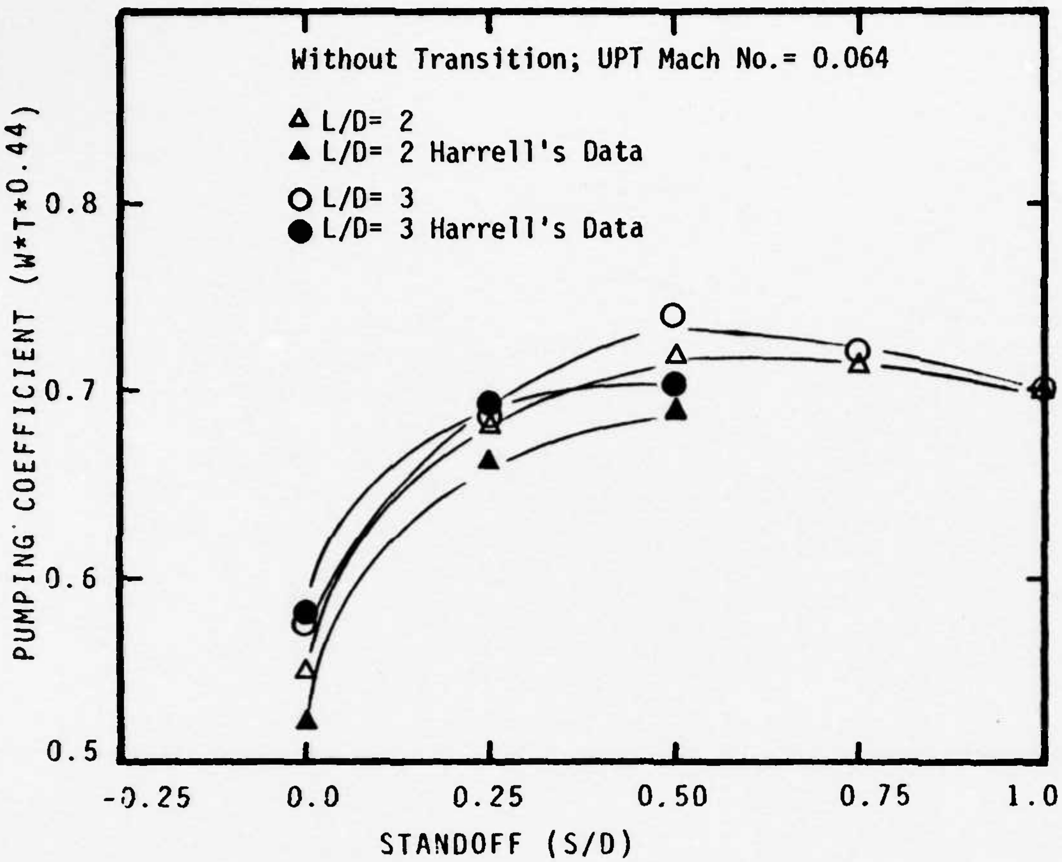


FIGURE 29. Plot of Pumping Coefficients versus Standoff; Parametric in Mixing Stack Length without a Conical Transition

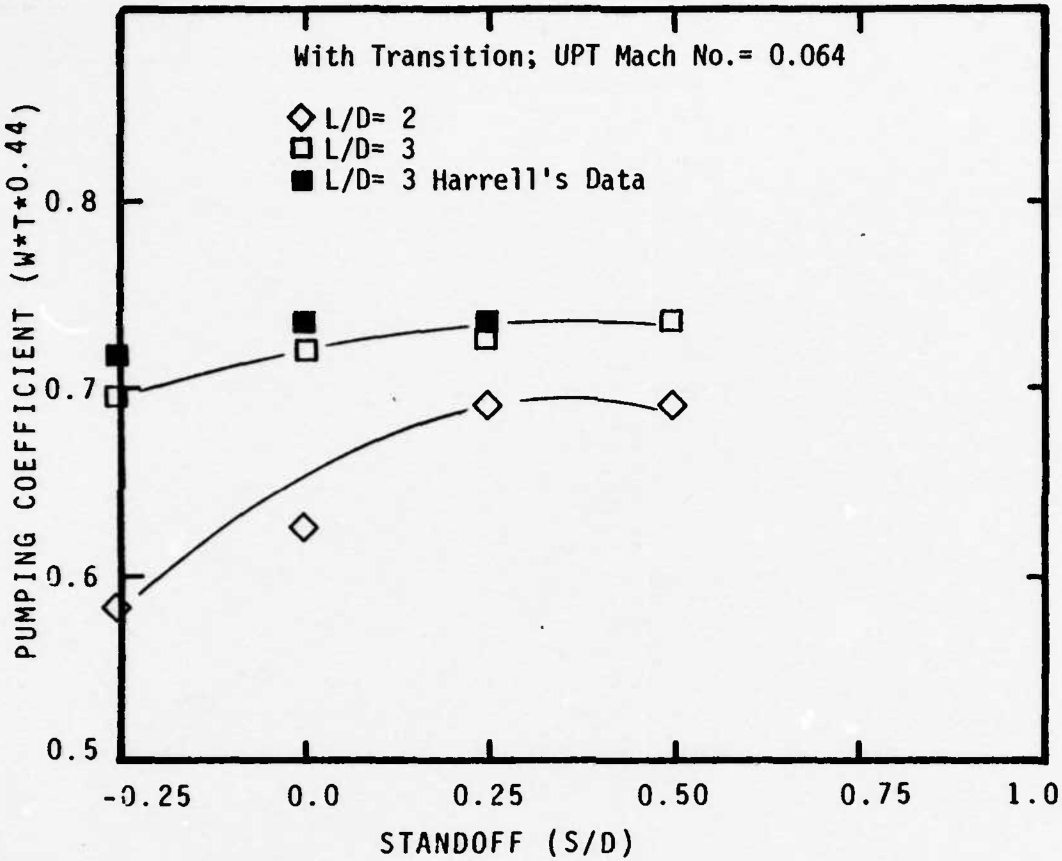


FIGURE 30. Plot of Pumping Coefficient versus Standoff; Parametric in Mixing Stack Length with a Conical Transition

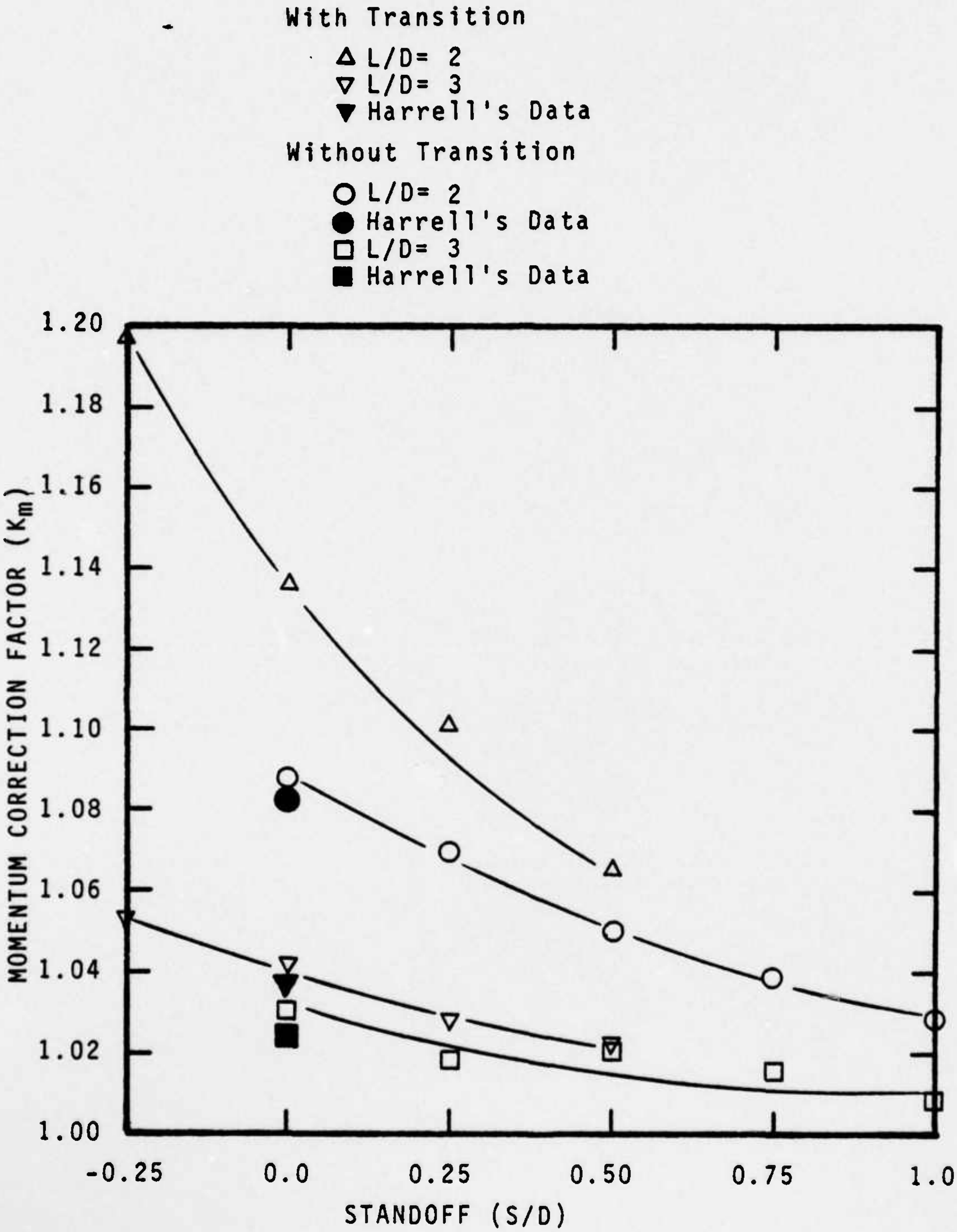


FIGURE 31. Plot of Momentum Correction Factors Versus Standoff; Parametric in Mixing Stack Length

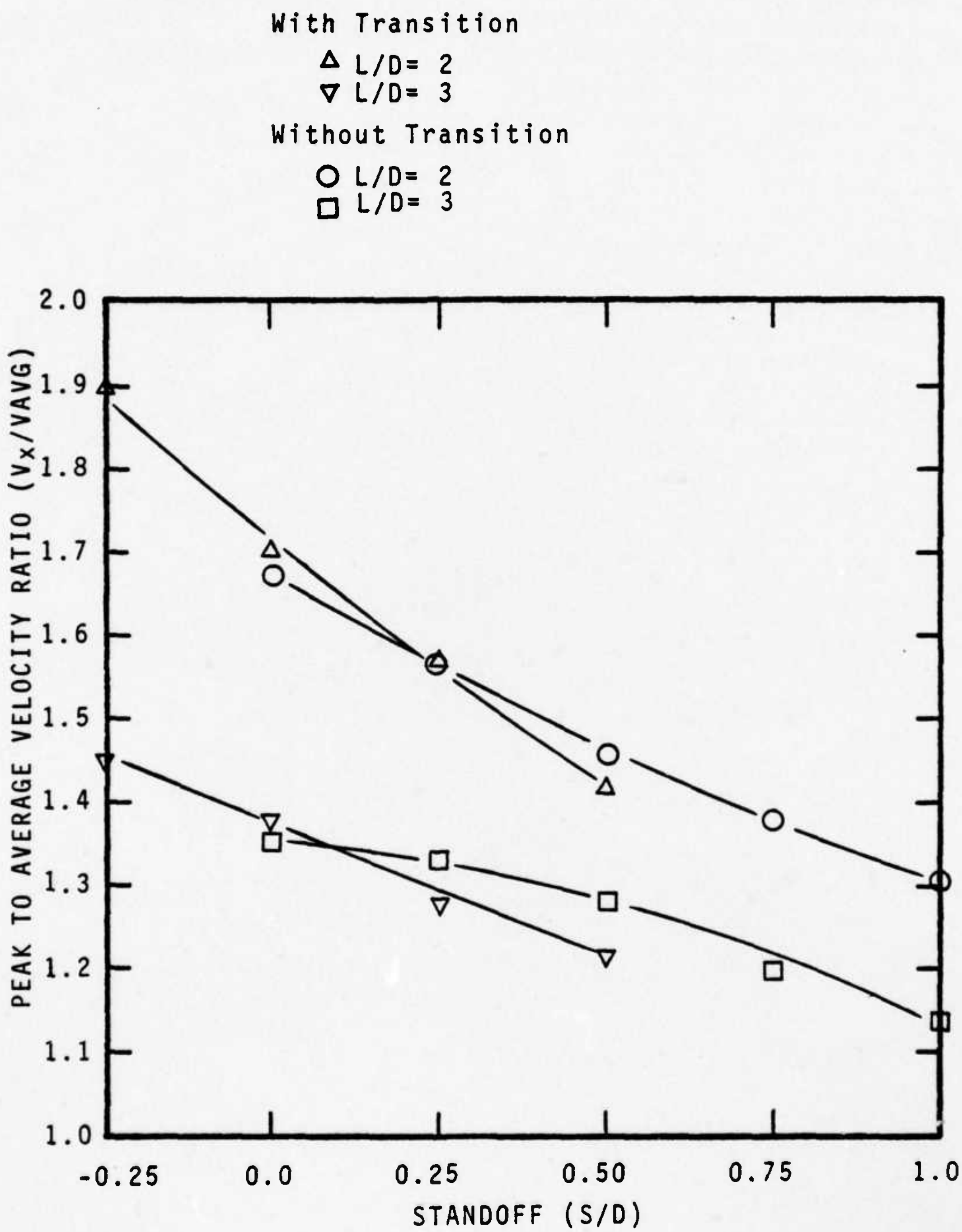


FIGURE 32. Plot of Peak to Average Velocity Ratio Versus Standoff; Parametric in Mixing Stack Length

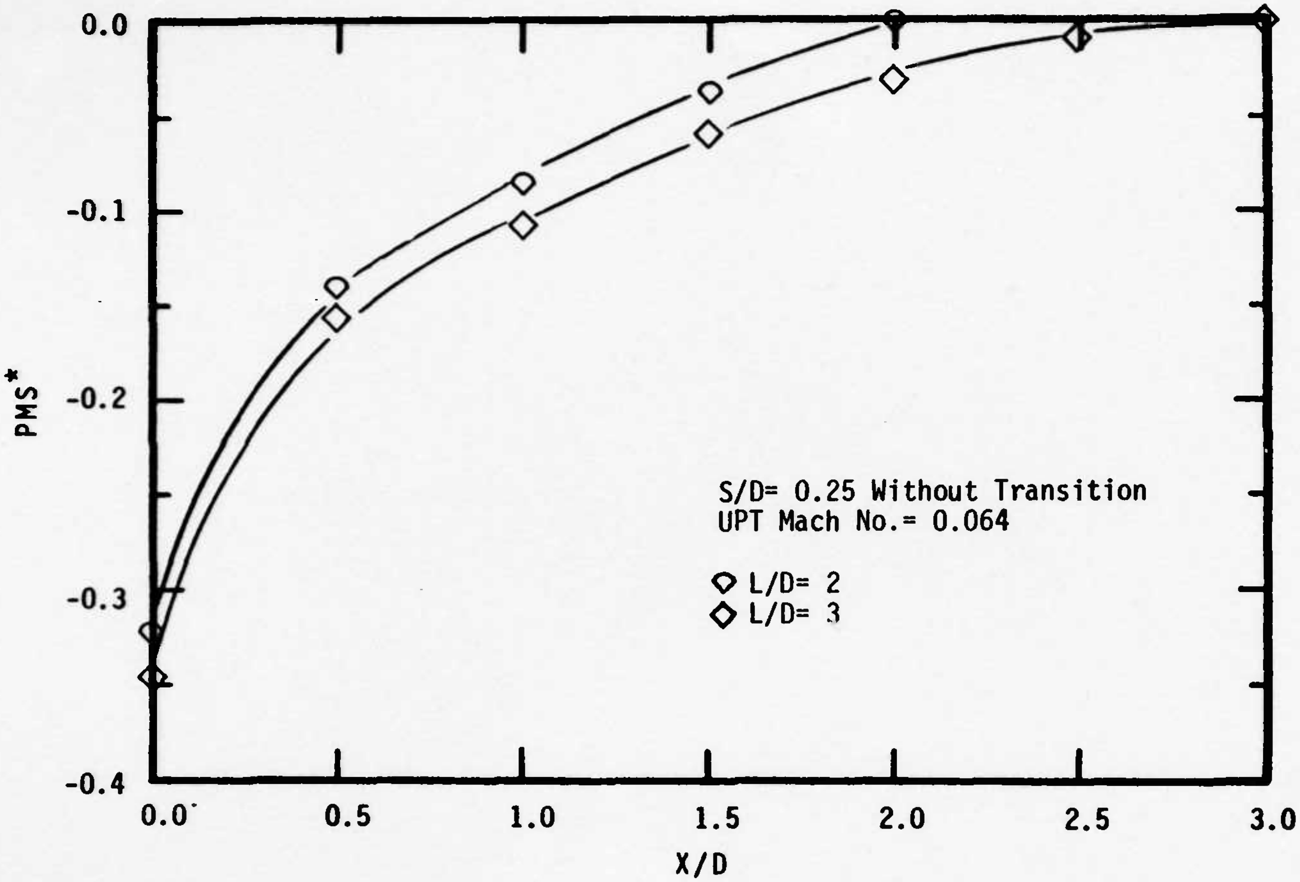


FIGURE 33. Effect of Mixing Stack Length on Mixing Stack Pressure Distribution Without a Conical Transition

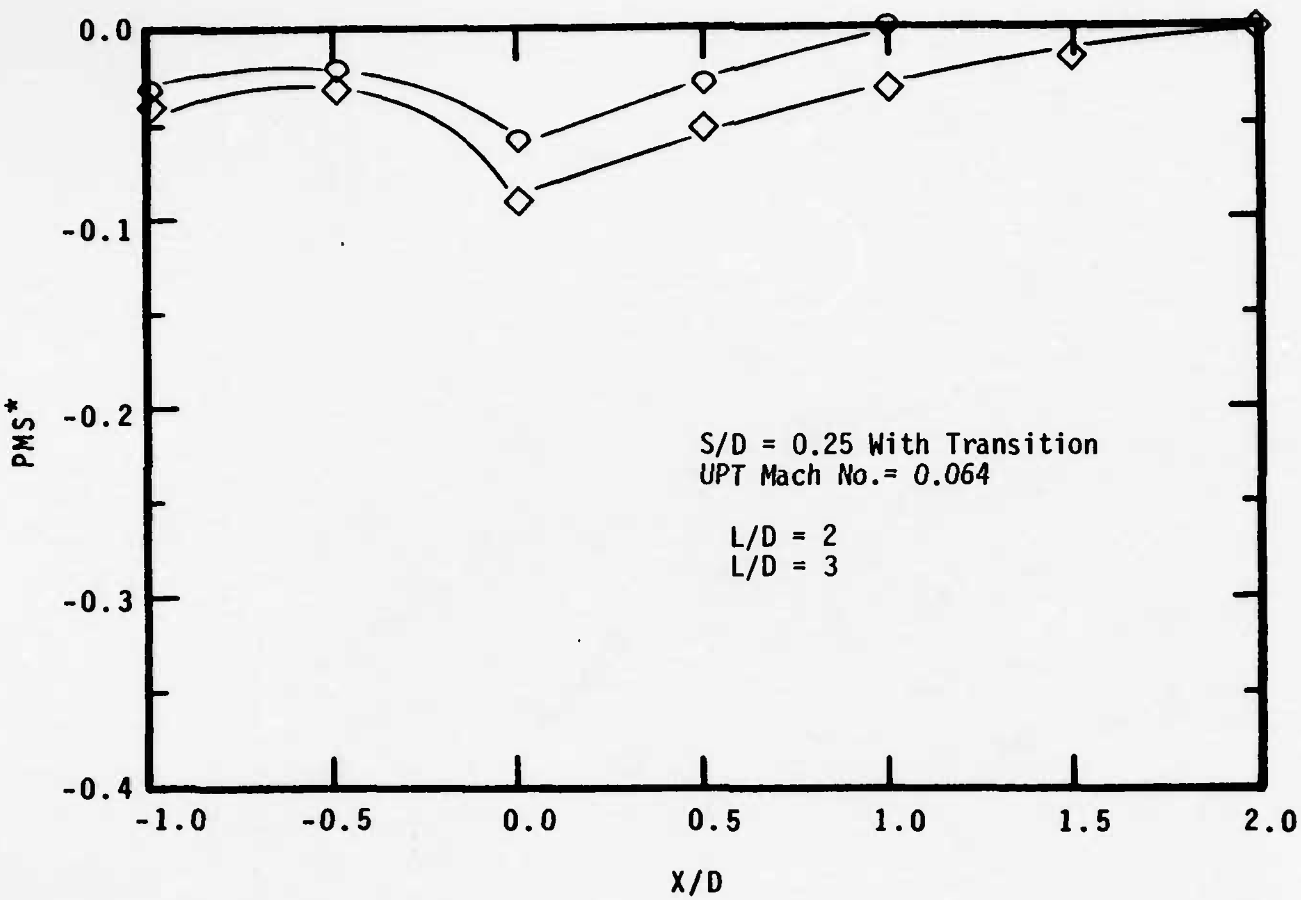


FIGURE 34. Effect of Mixing Stack Length on Mixing Stack Pressure Distribution With a Conical Transition

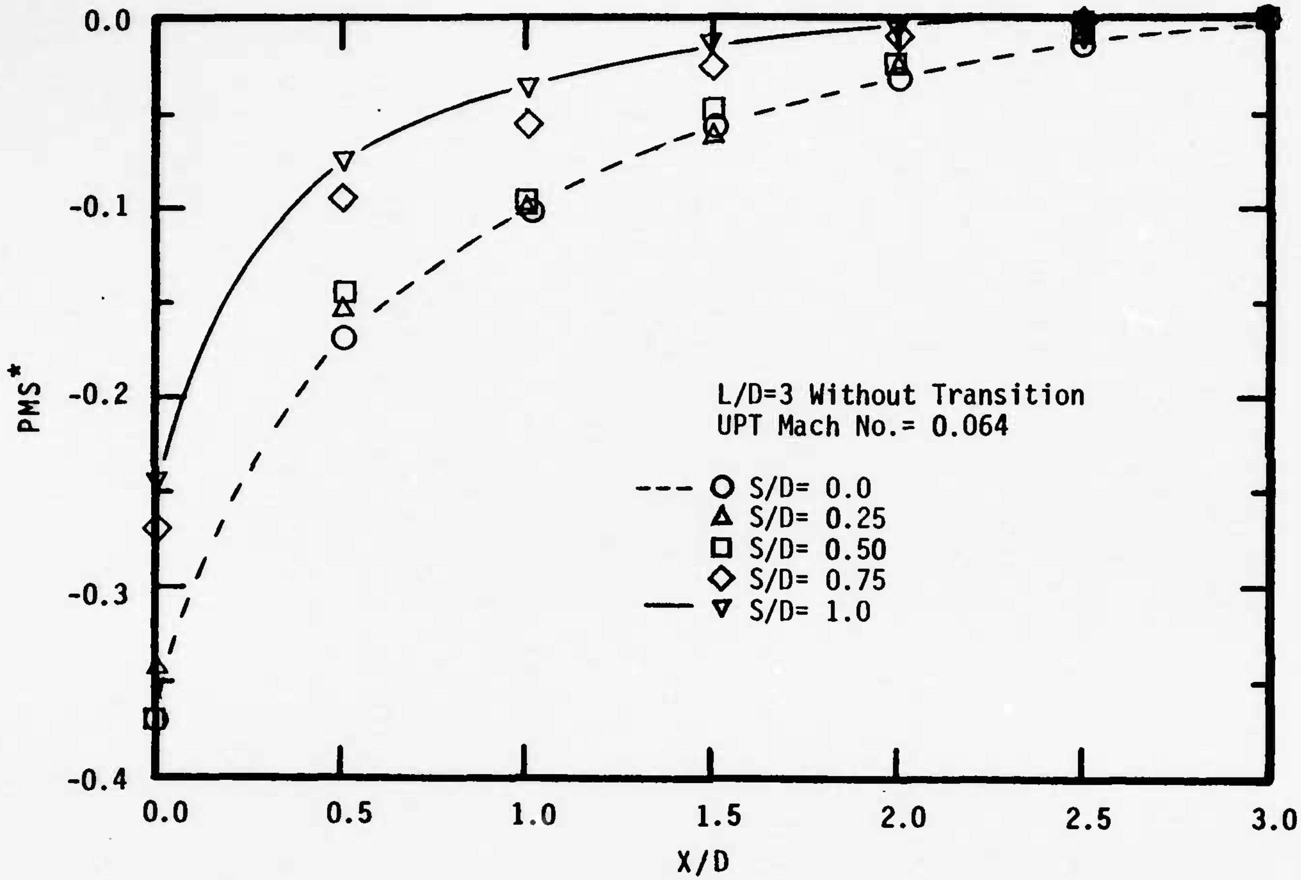


FIGURE 35. Effect of Standoff on Mixing Stack Pressure Distribution

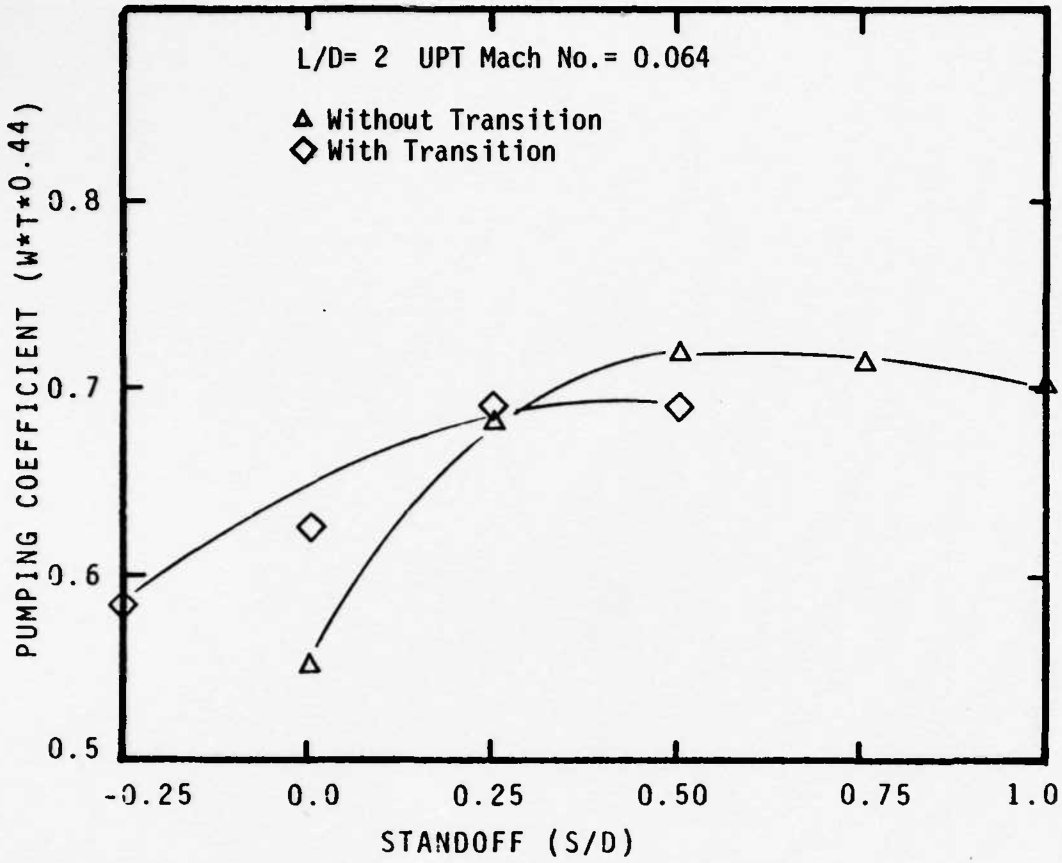


FIGURE 36. Effect of the Conical Transition on Pumping Coefficients for a Mixing Stack of Length L/D = 2

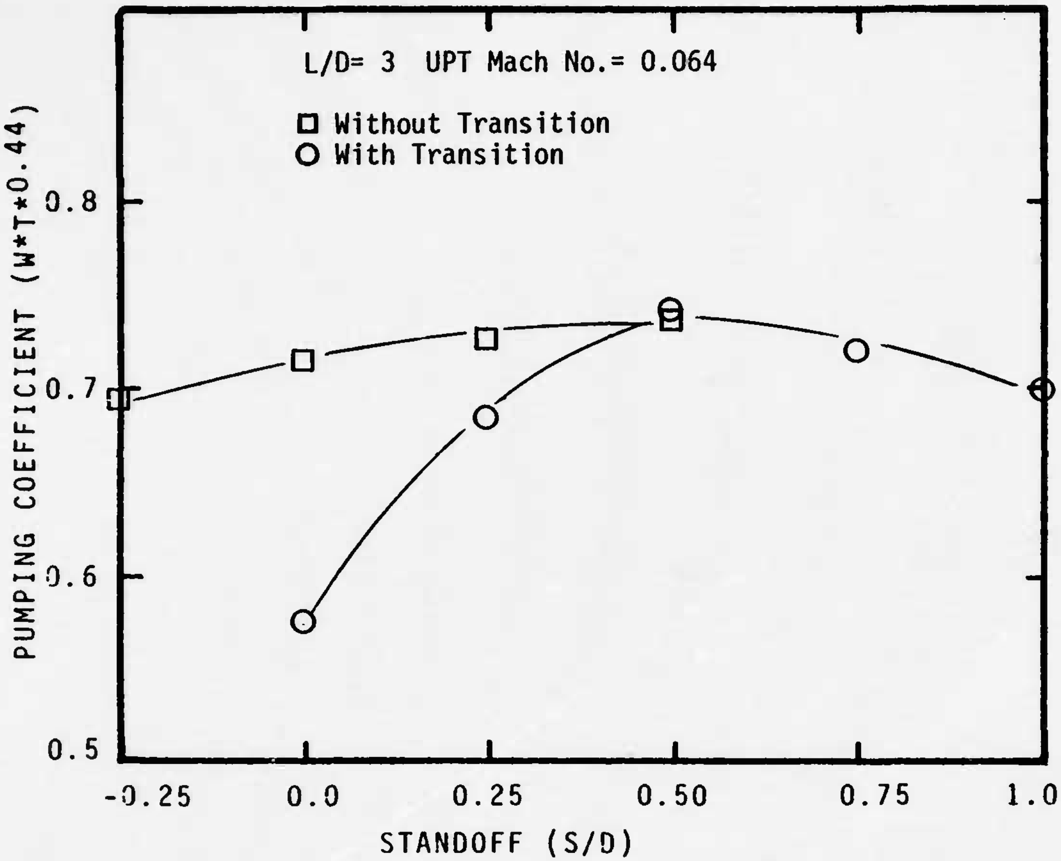


FIGURE 37. Effect of the Conical Transition on Pumping Coefficients for a Mixing Stack of Length L/D = 3

37

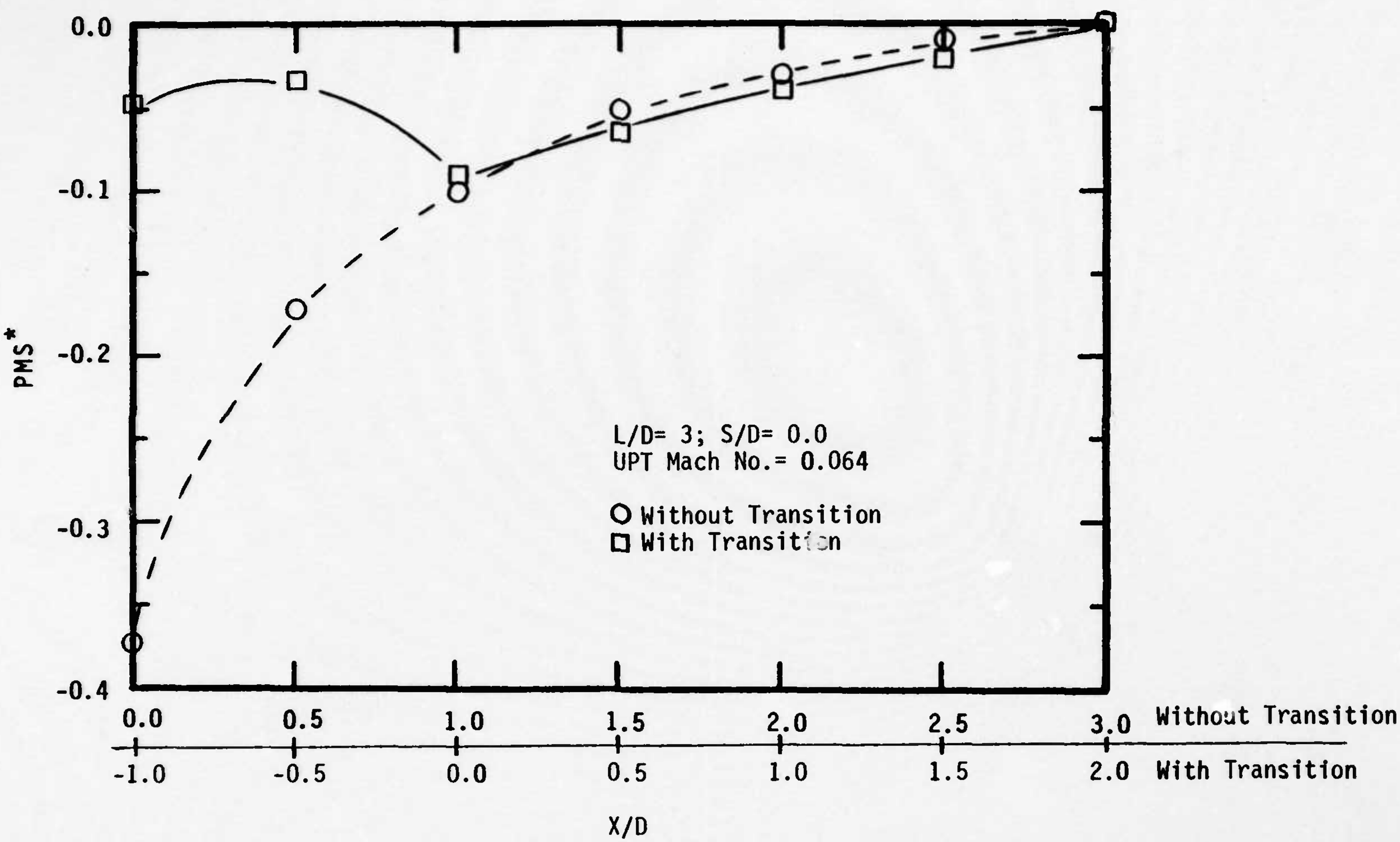


FIGURE 38. Effect of the Conical Transition on the Mixing Stack Pressure Distribution For Standoff = 0.0.

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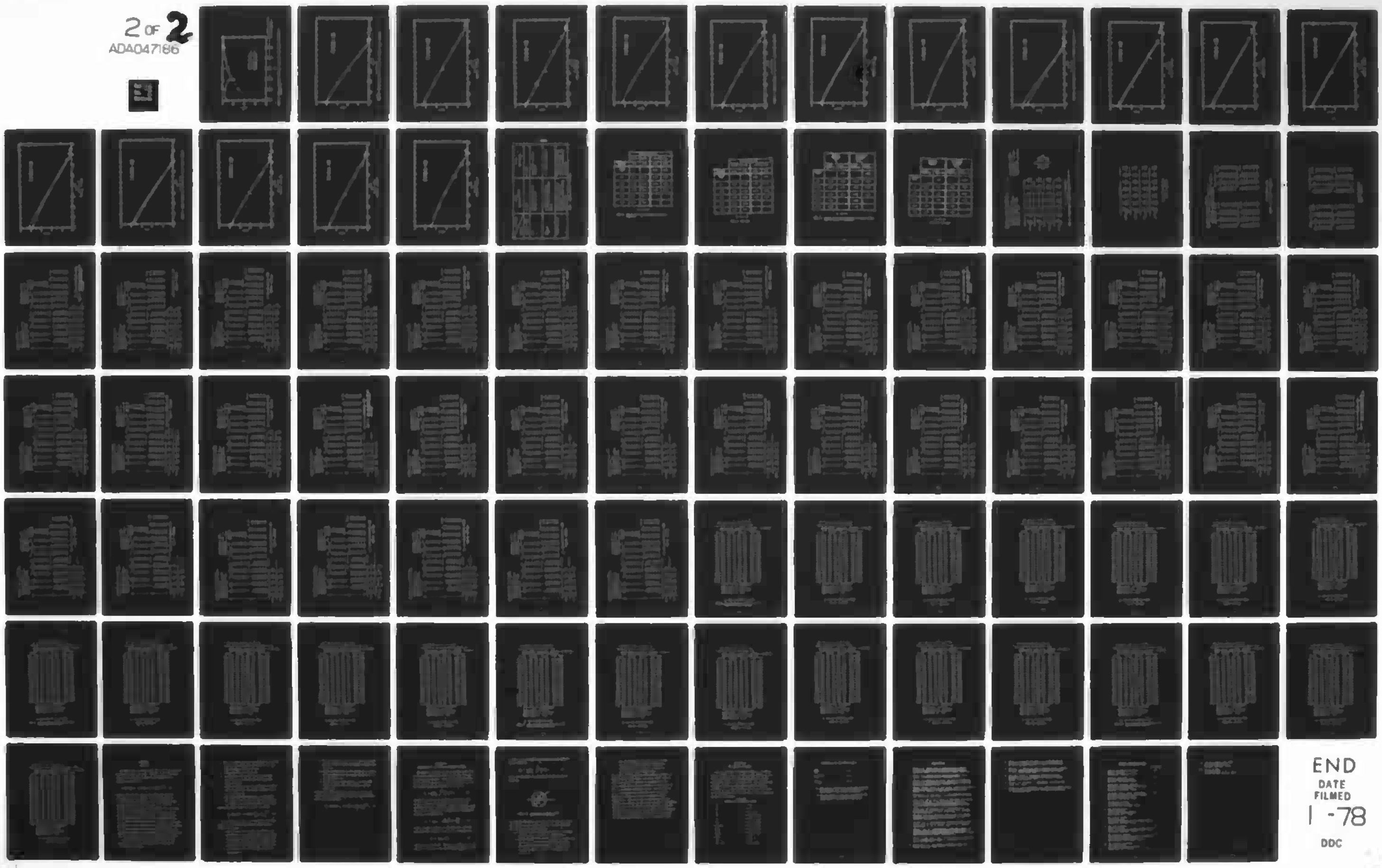

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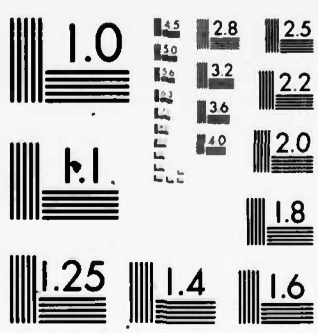

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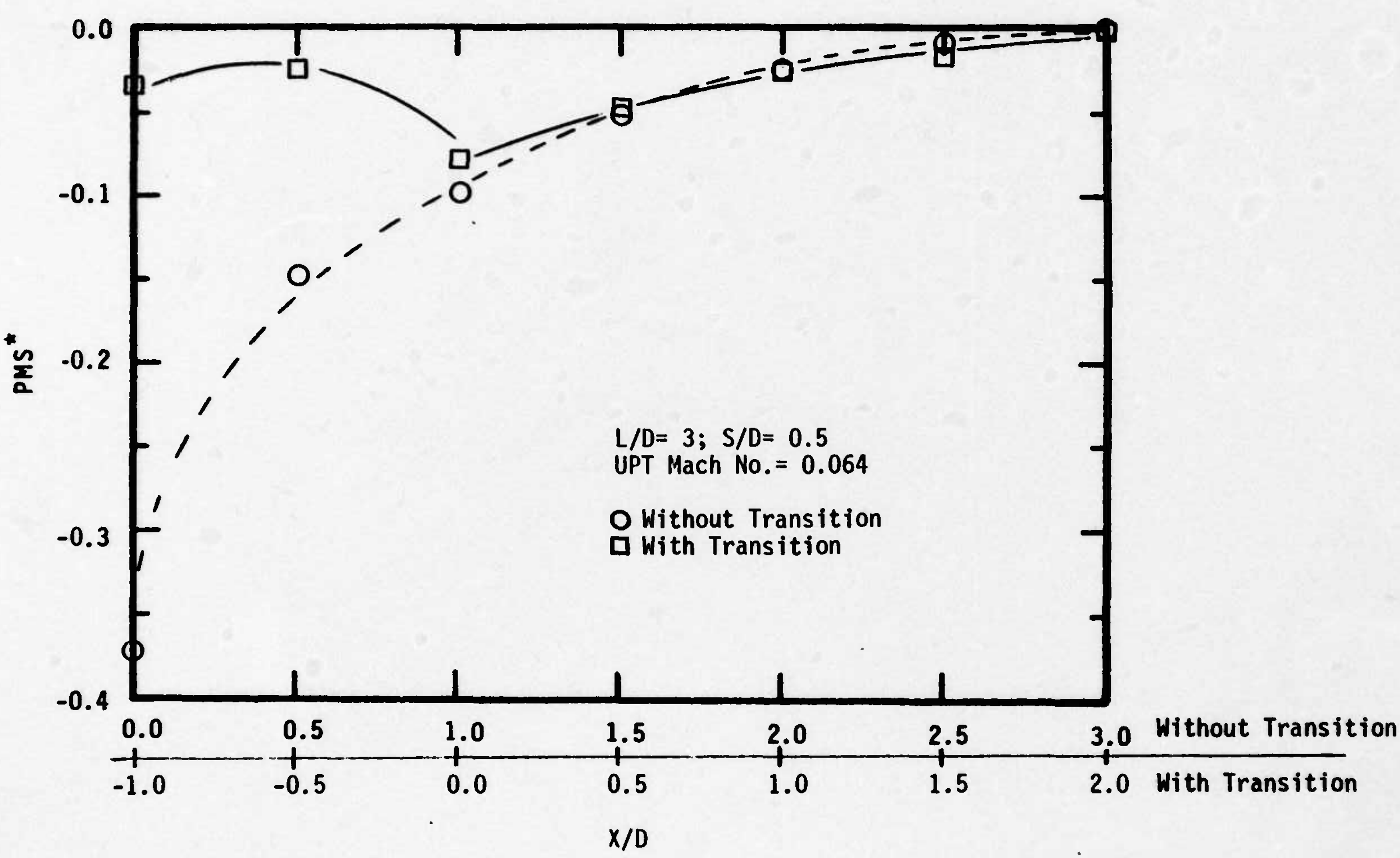
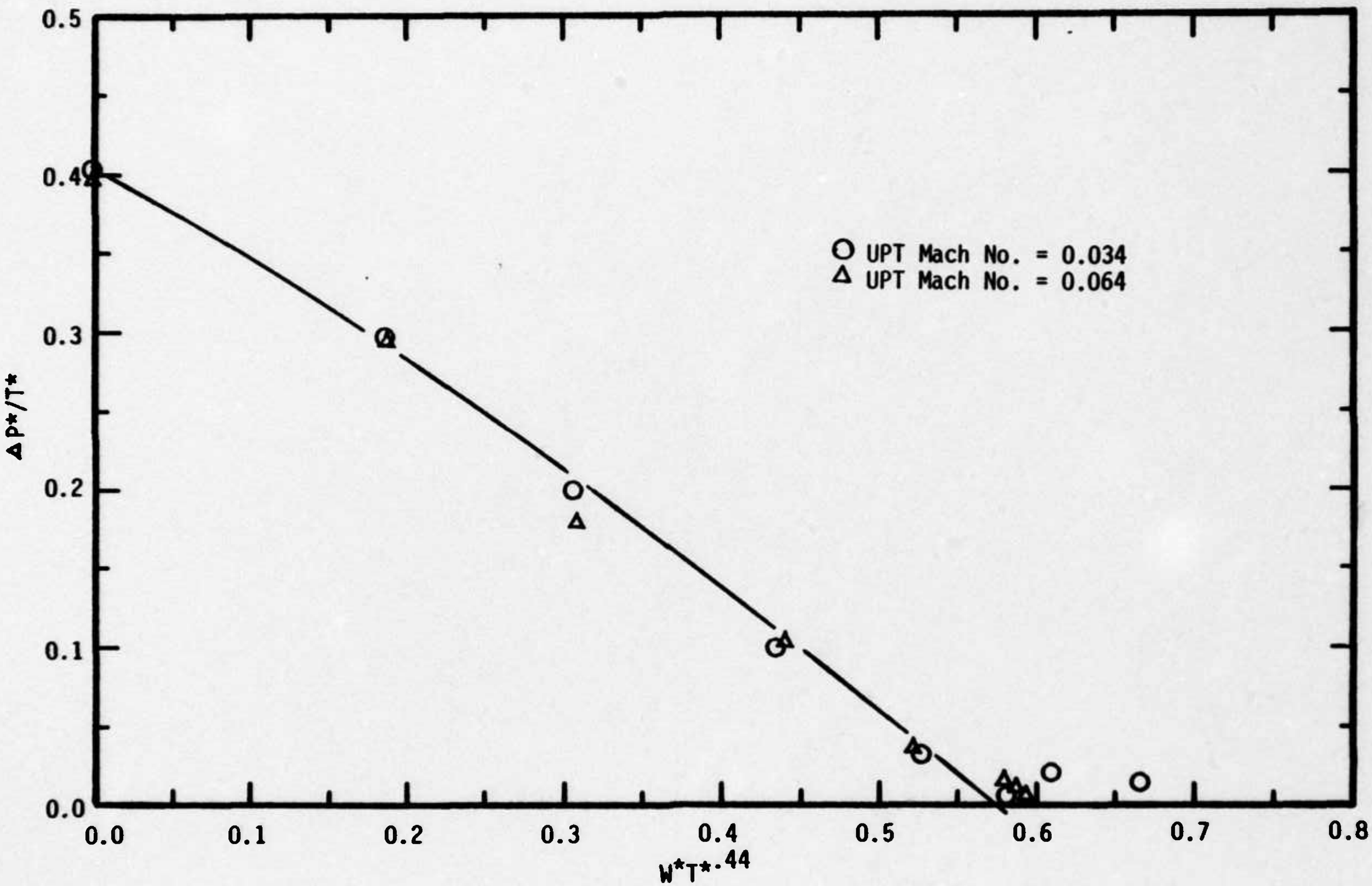
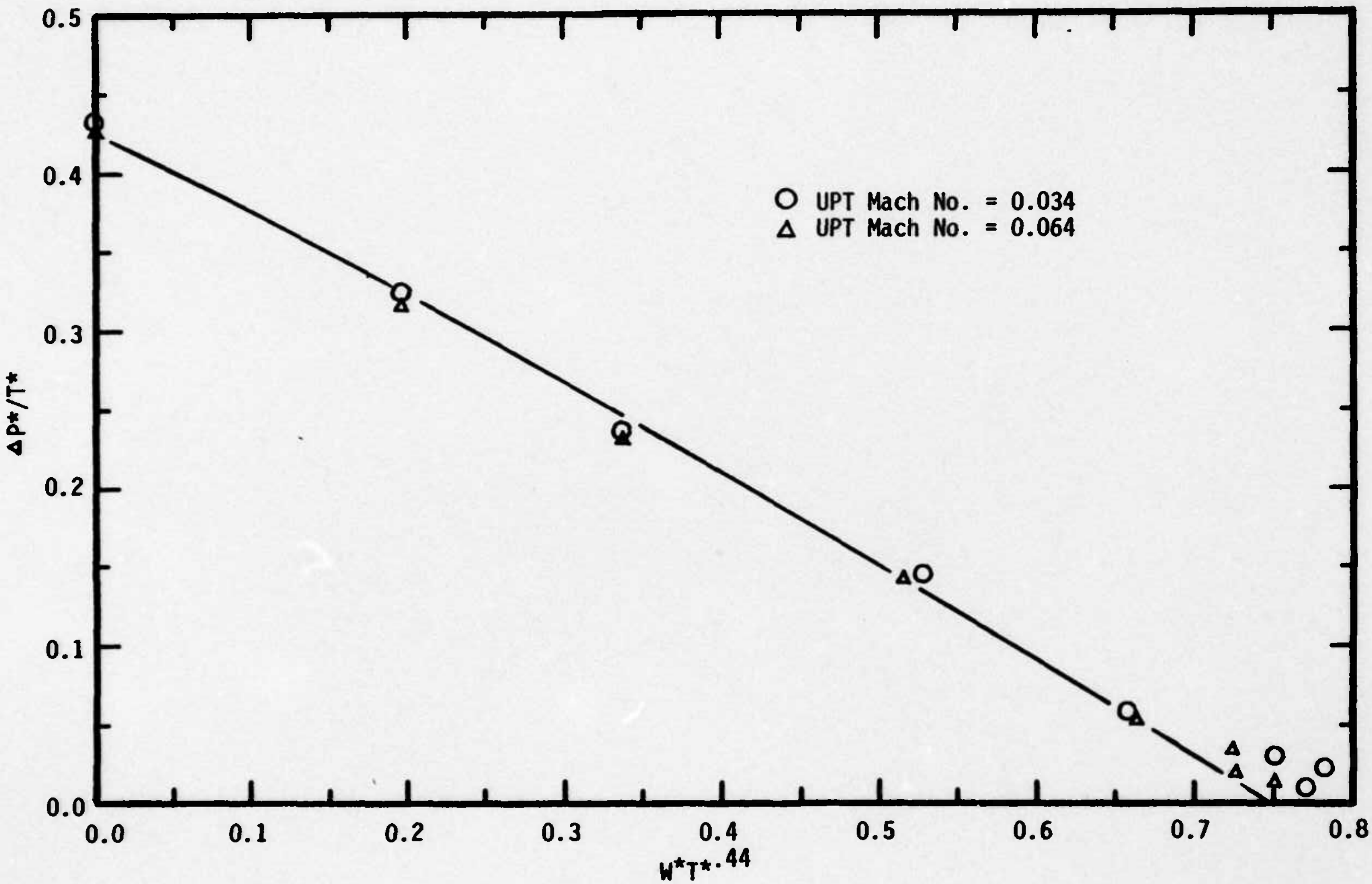


FIGURE 39. Effect of the Conical Transition on the Mixing Stack Pressure Distribution For Standoff= 0.5.



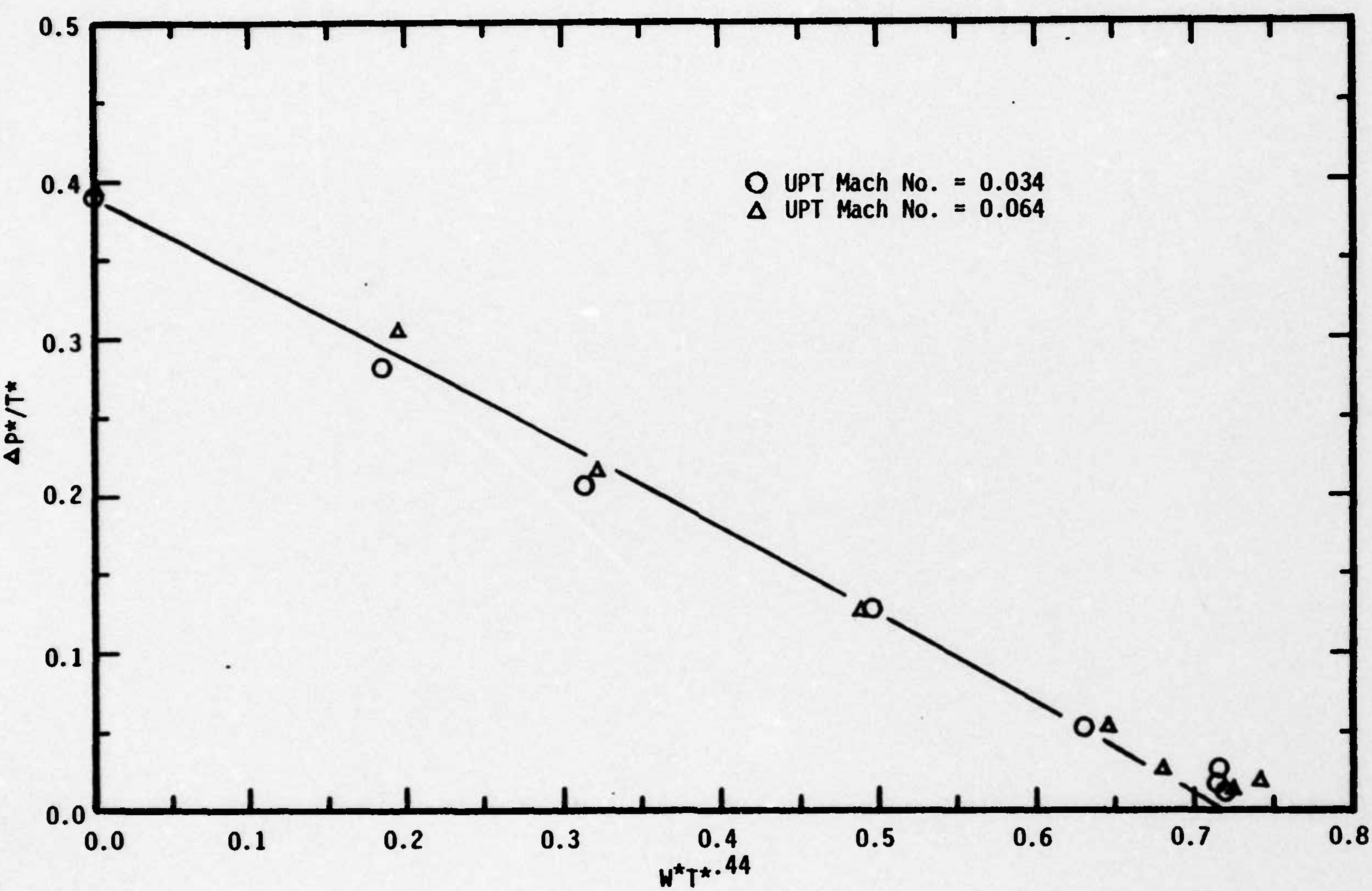
a) S/D = 0.0

FIGURE 40. Pumping Characteristic Curves for L/D = 3 with a Conical Transition



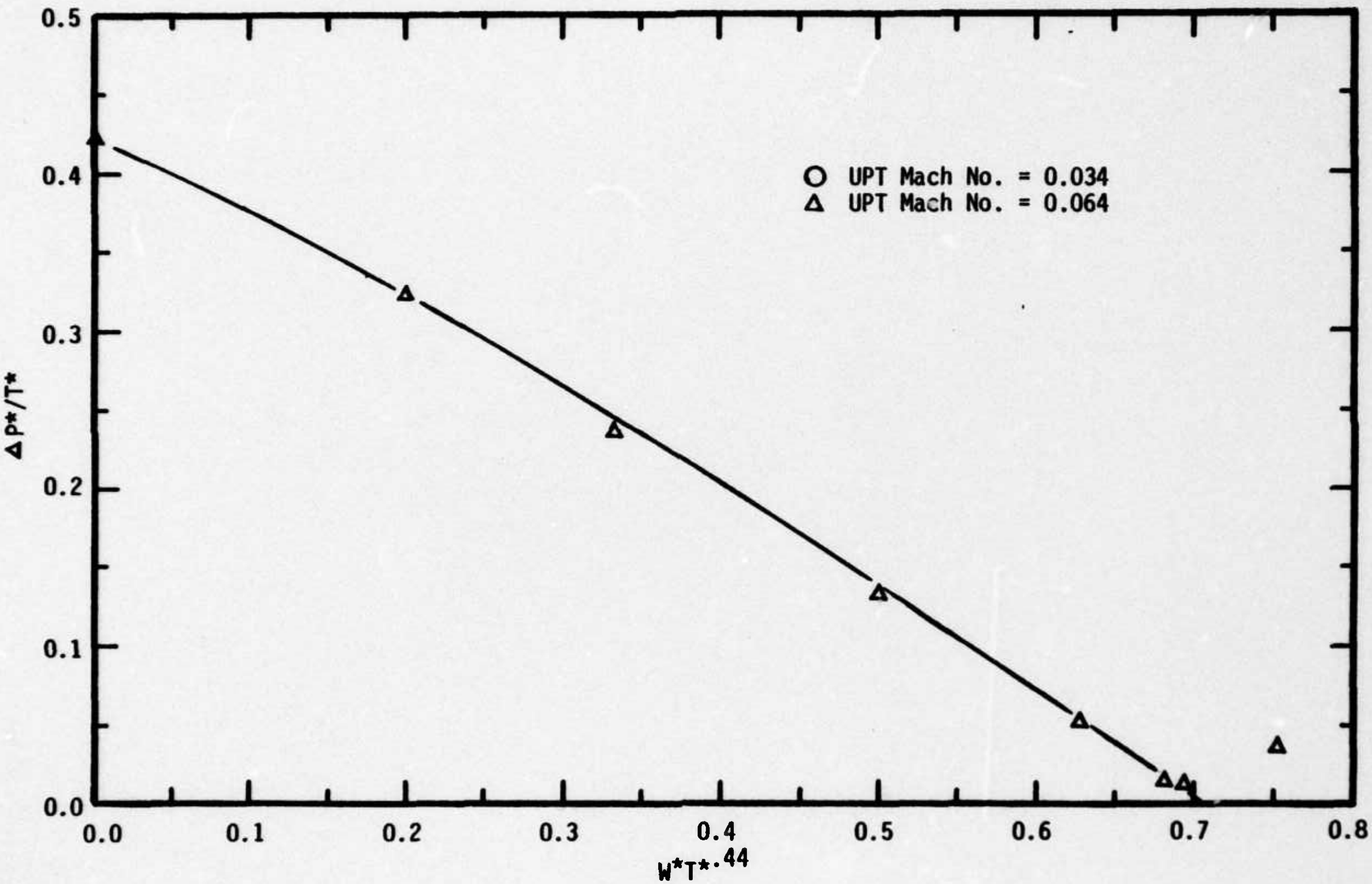
b) S/D = 0.50

FIGURE 40. Continued.



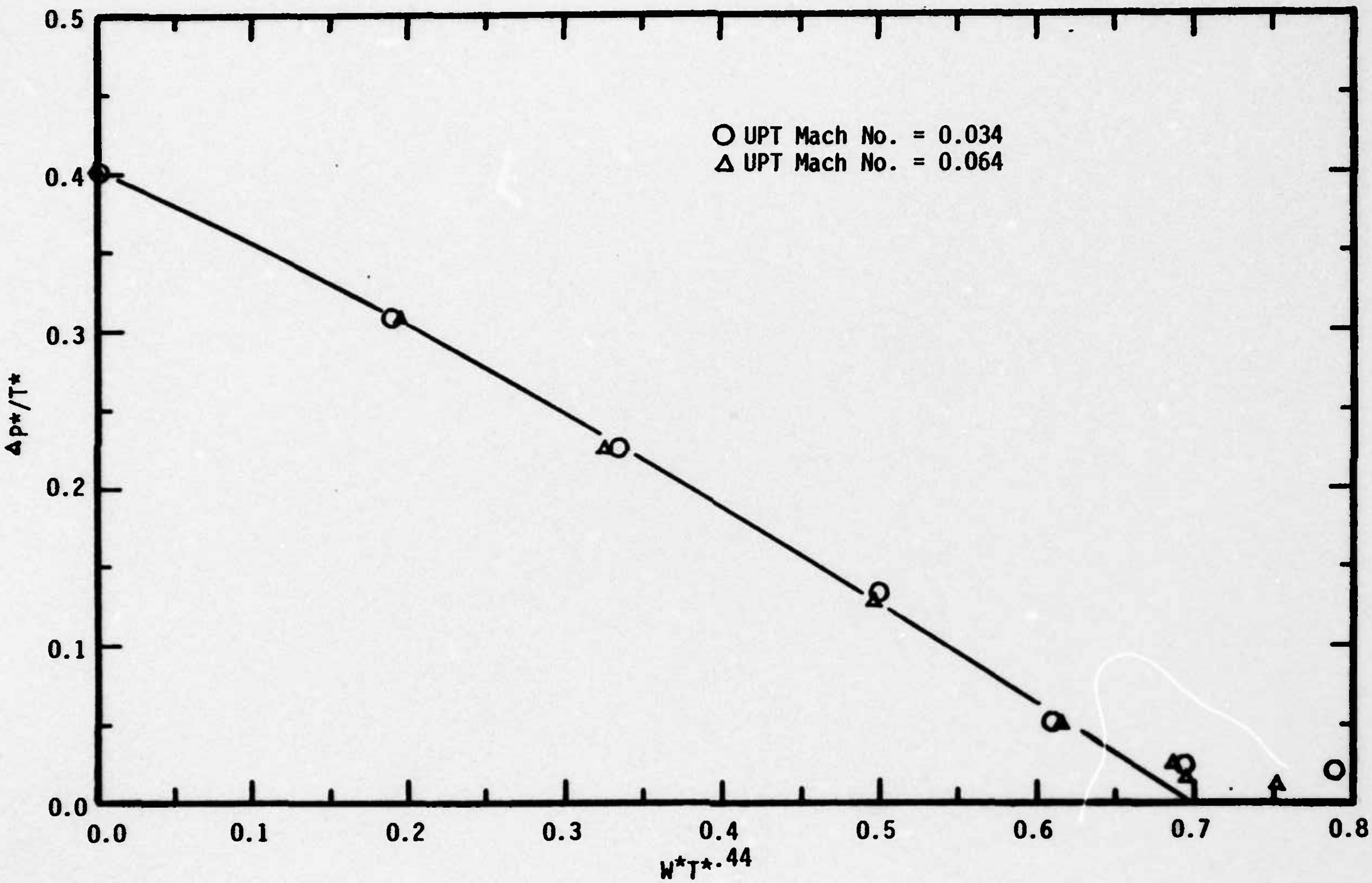
c) S/D = 0.75

FIGURE 40. Continued.



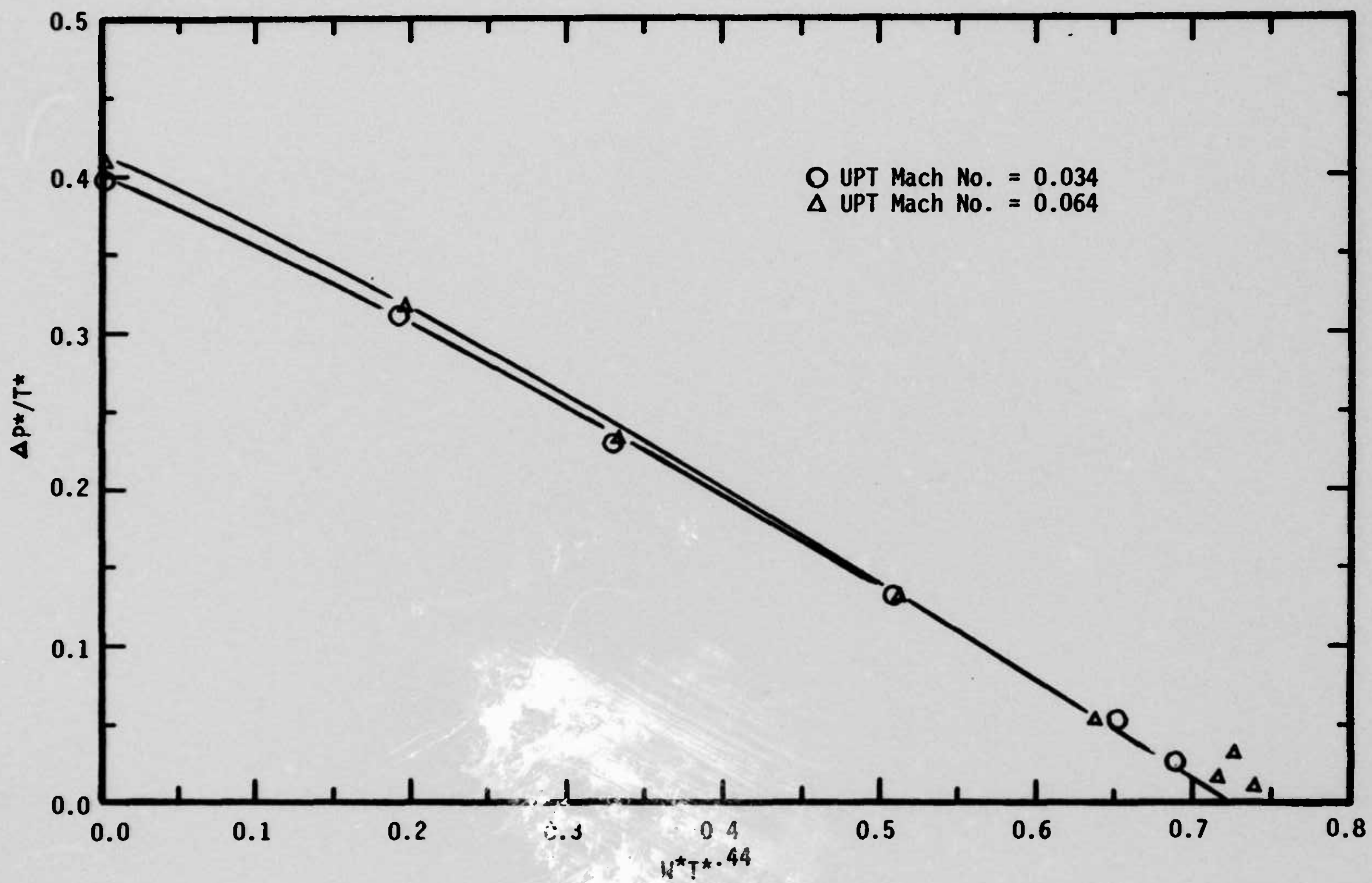
d) S/D = 1.0

FIGURE 40. Continued.



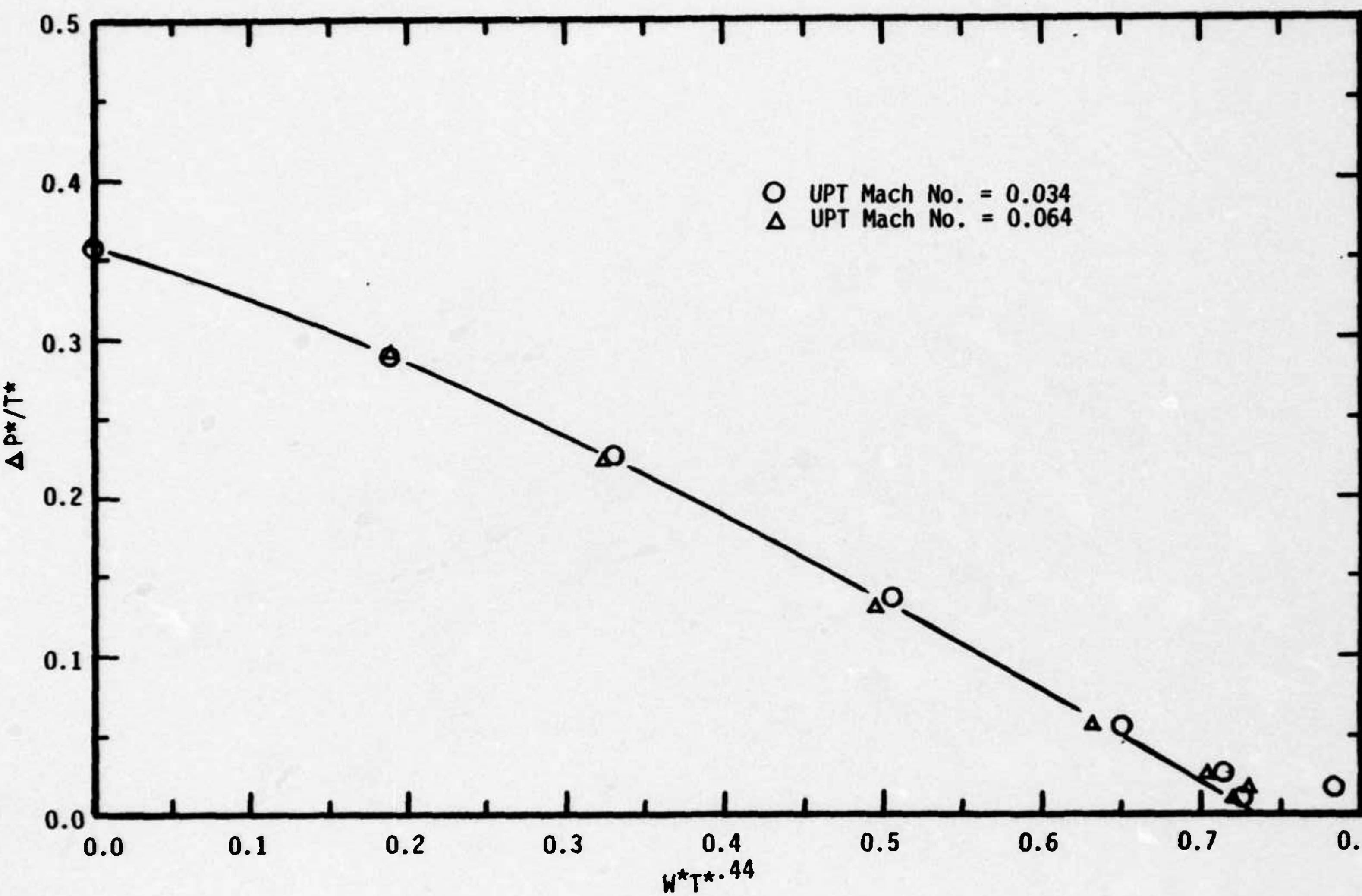
a) S/D = -0.25

FIGURE 41. Pumping Characteristic Curve for L/D = 3 with a Conical Transition



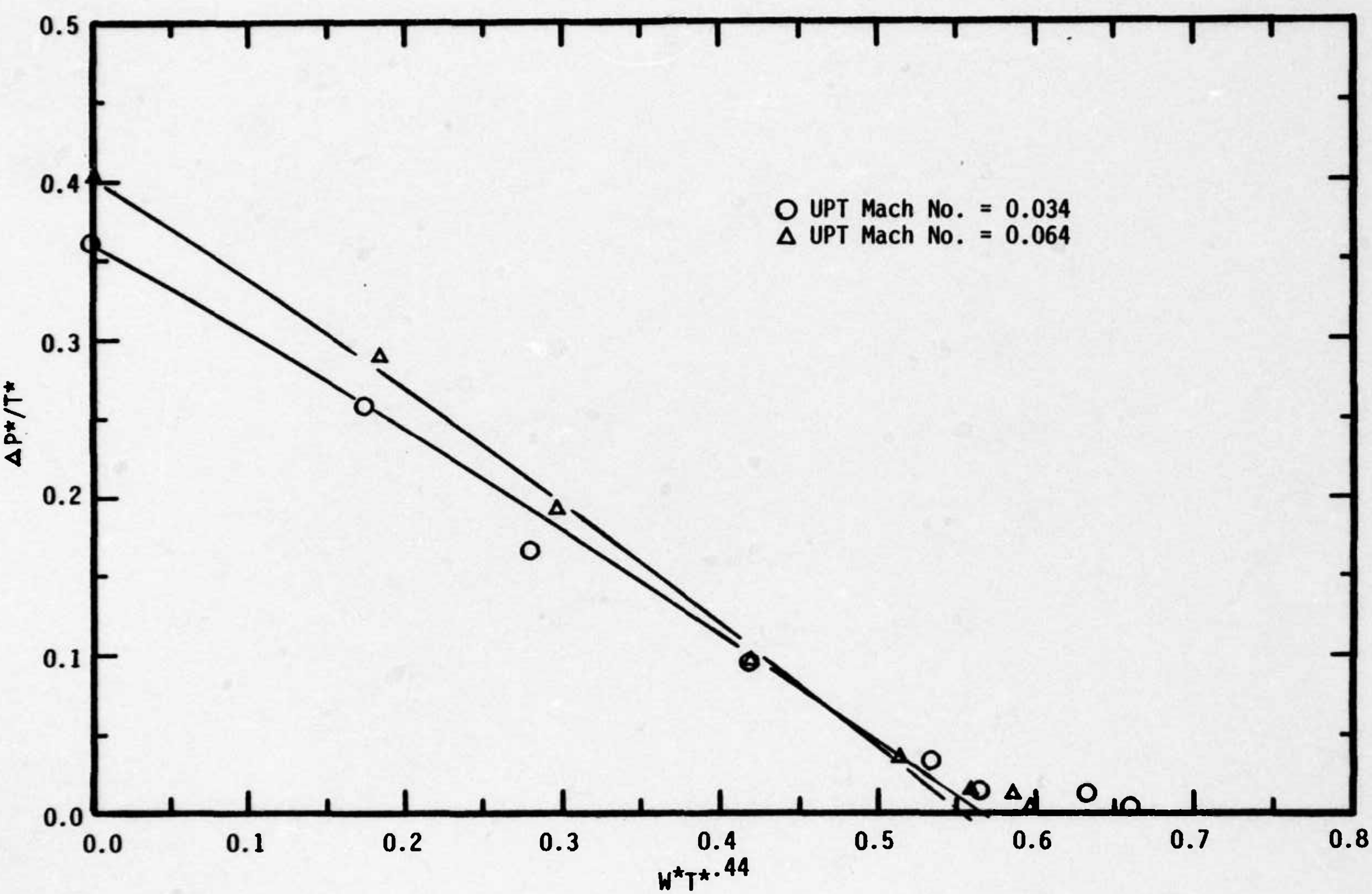
b) S/D = 0.0

FIGURE 41. Continued.



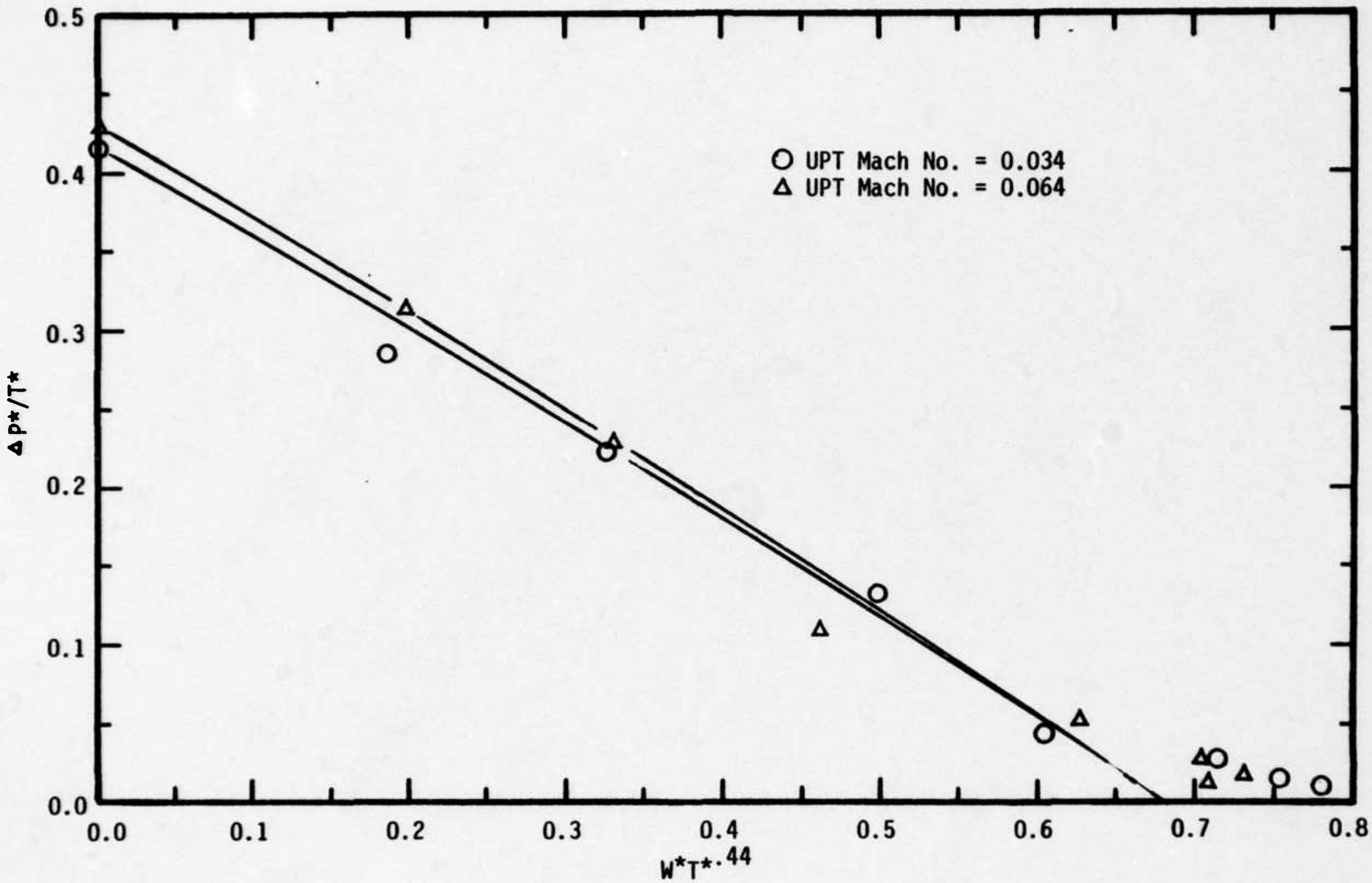
c) S/D = .50

FIGURE 41. Continued.



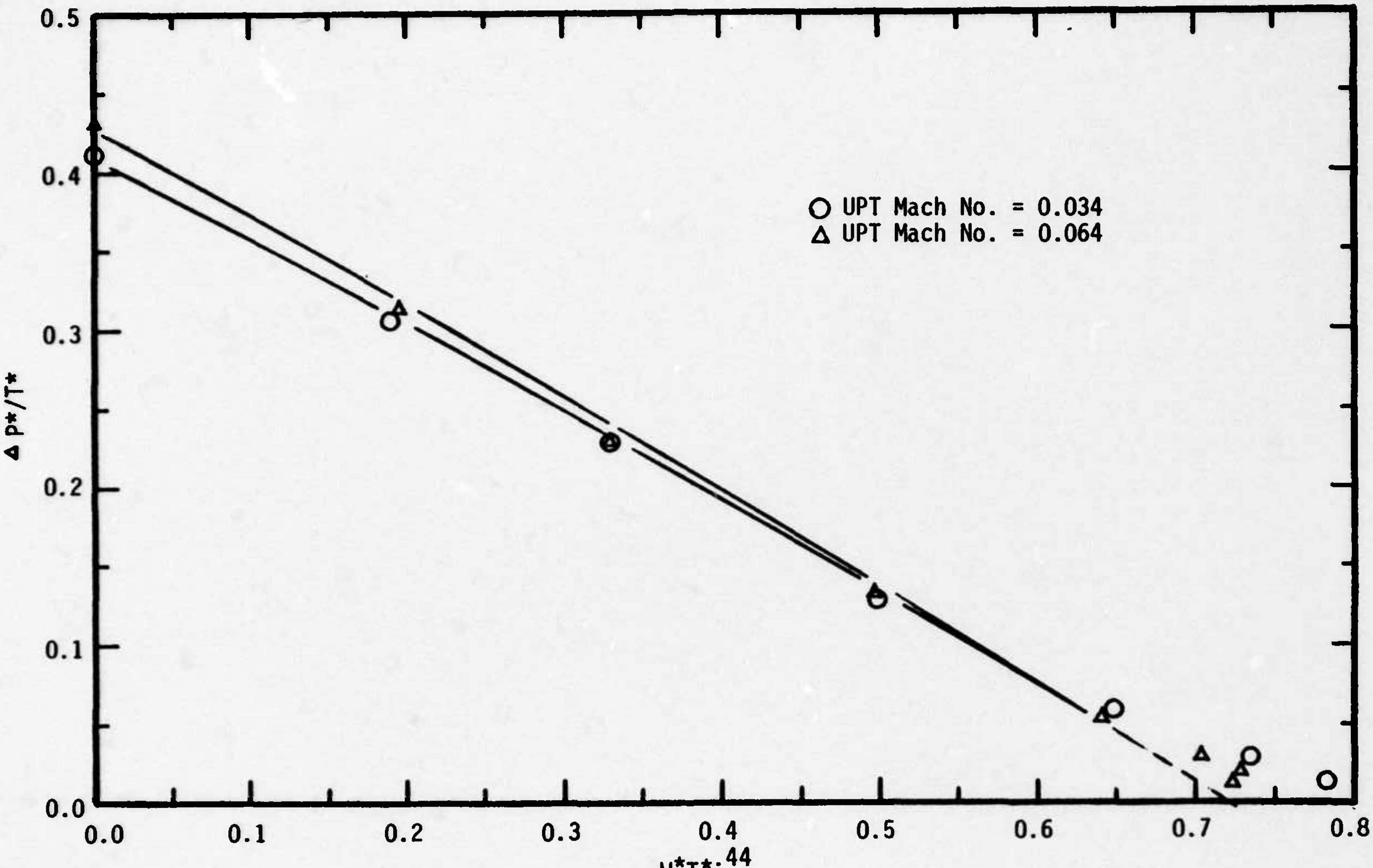
a) S/D = 0.0

FIGURE 42. Pumping Characteristc Curves for L/D = 2 Without a Conical Transition



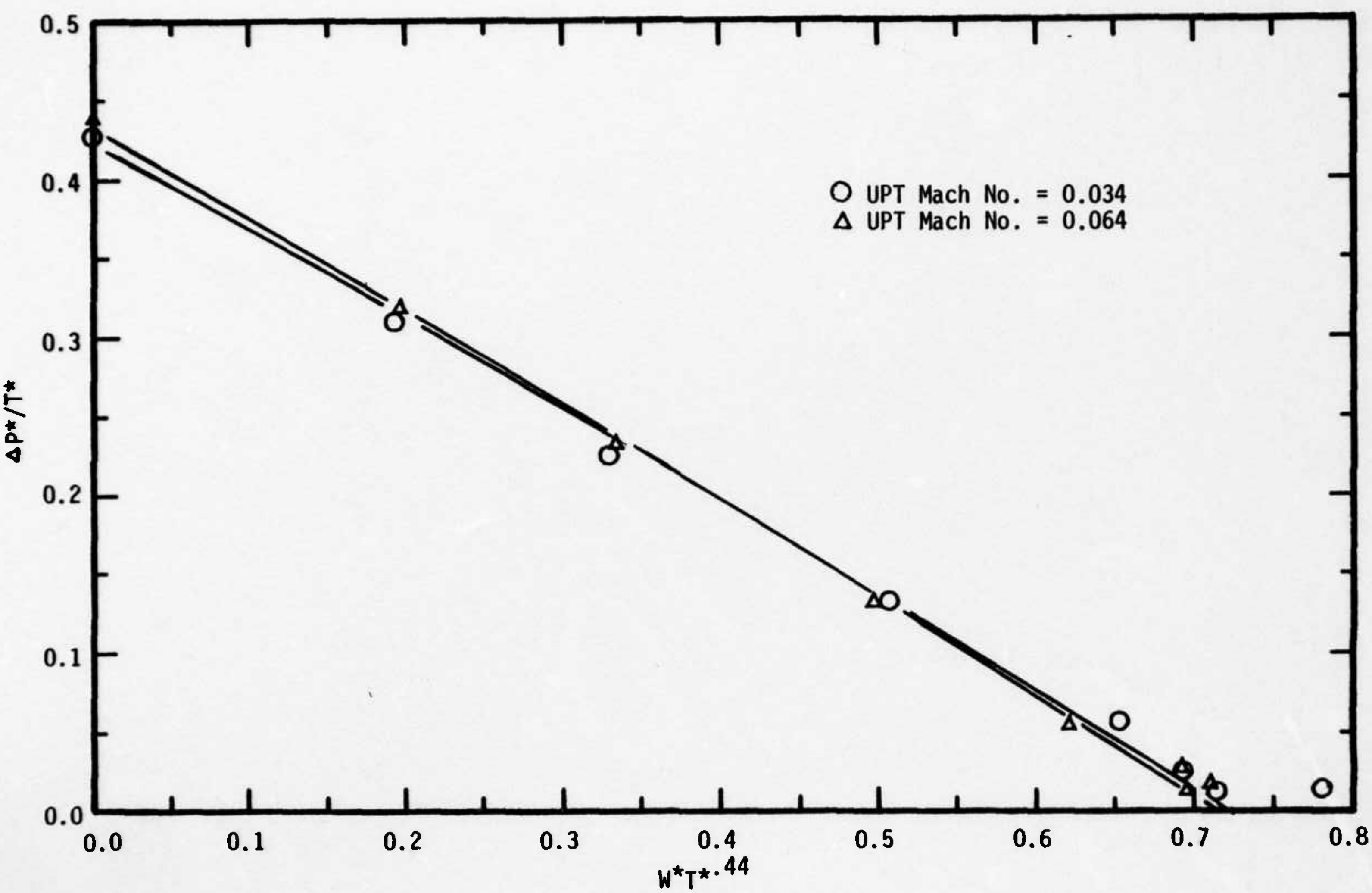
b) S/D = 0.25

FIGURE 42. Continued.



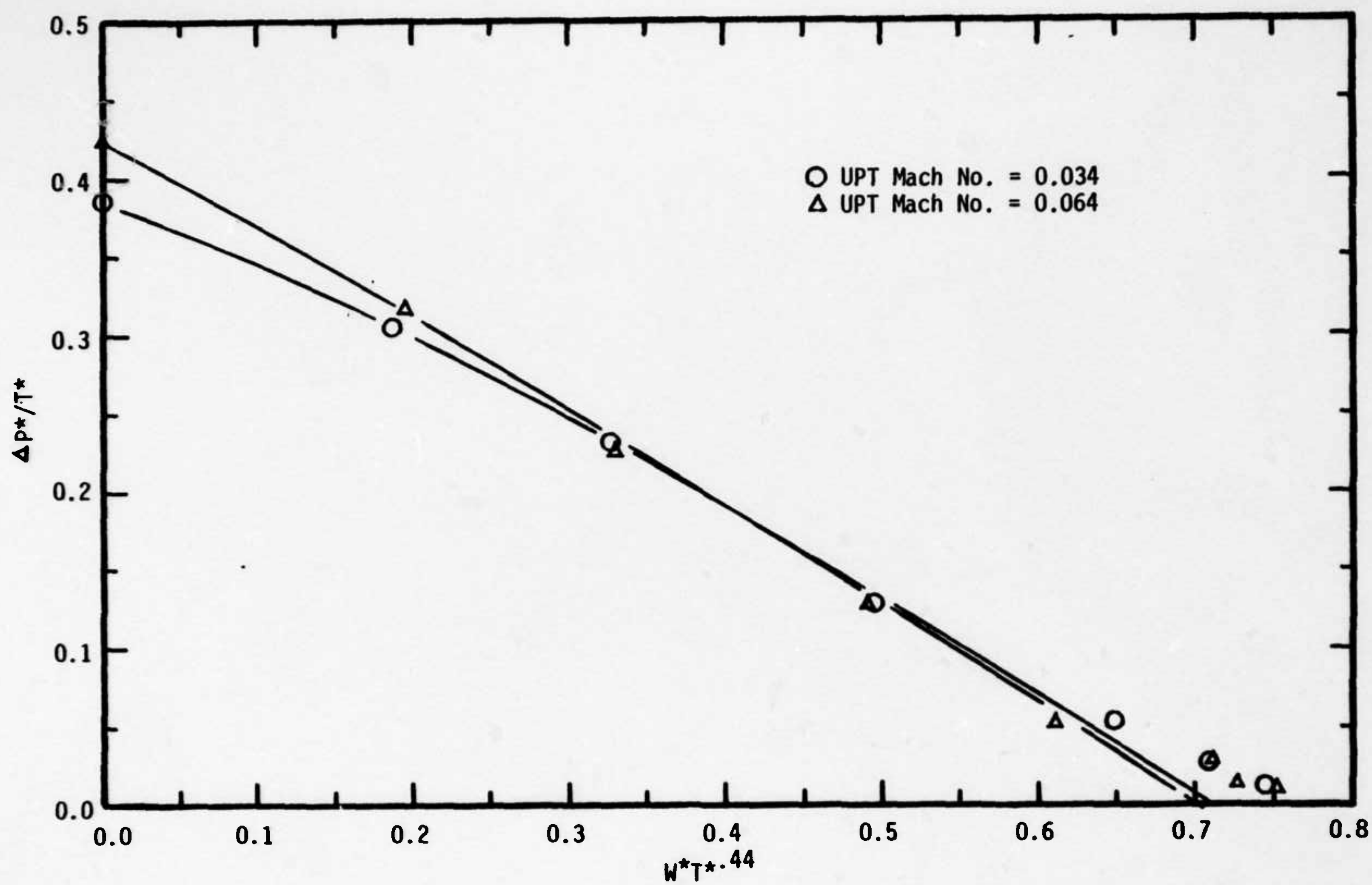
c) S/D = 0.50

FIGURE 42. Continued.



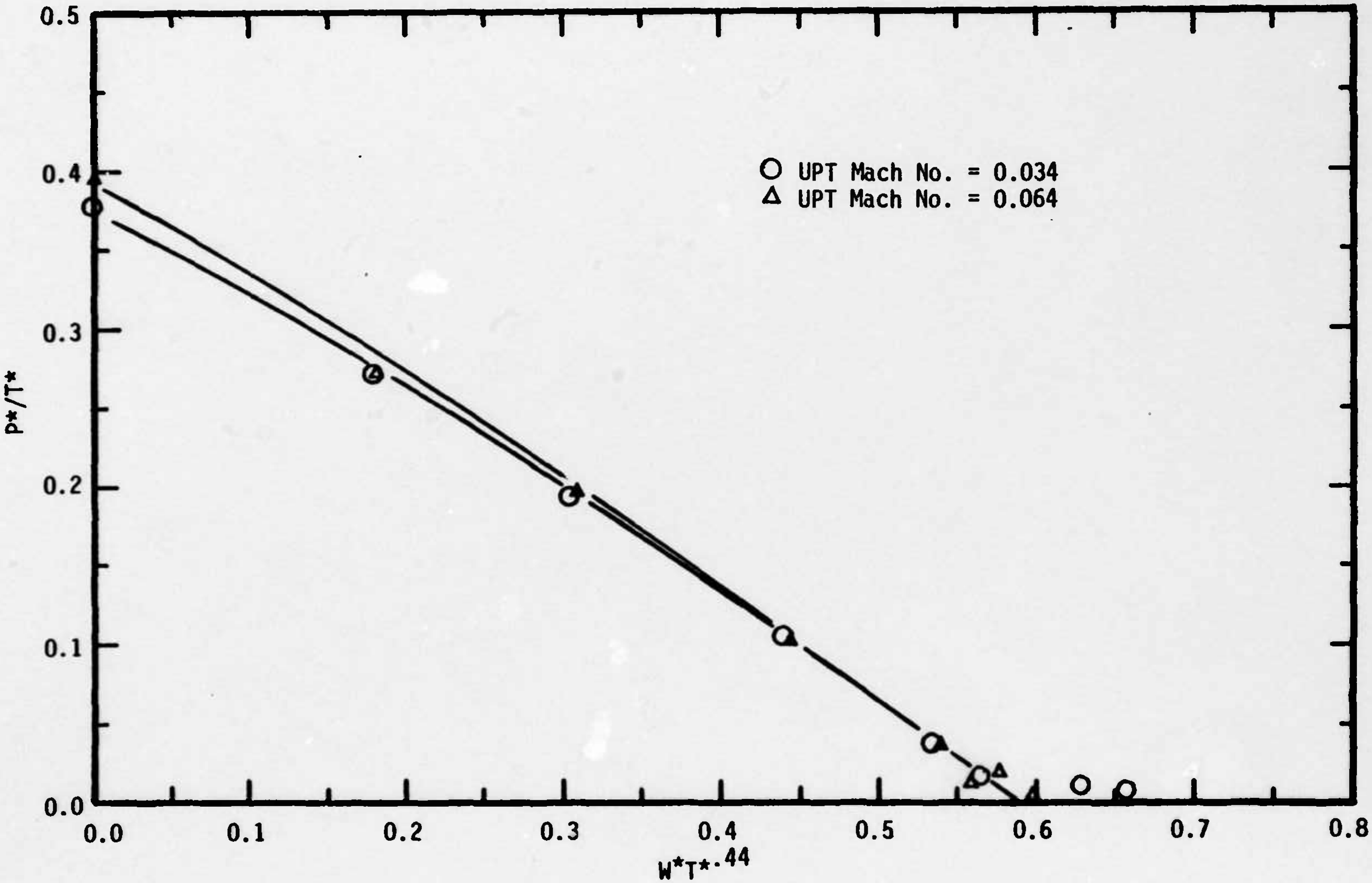
d) S/D = 0.75

FIGURE 42. Continued



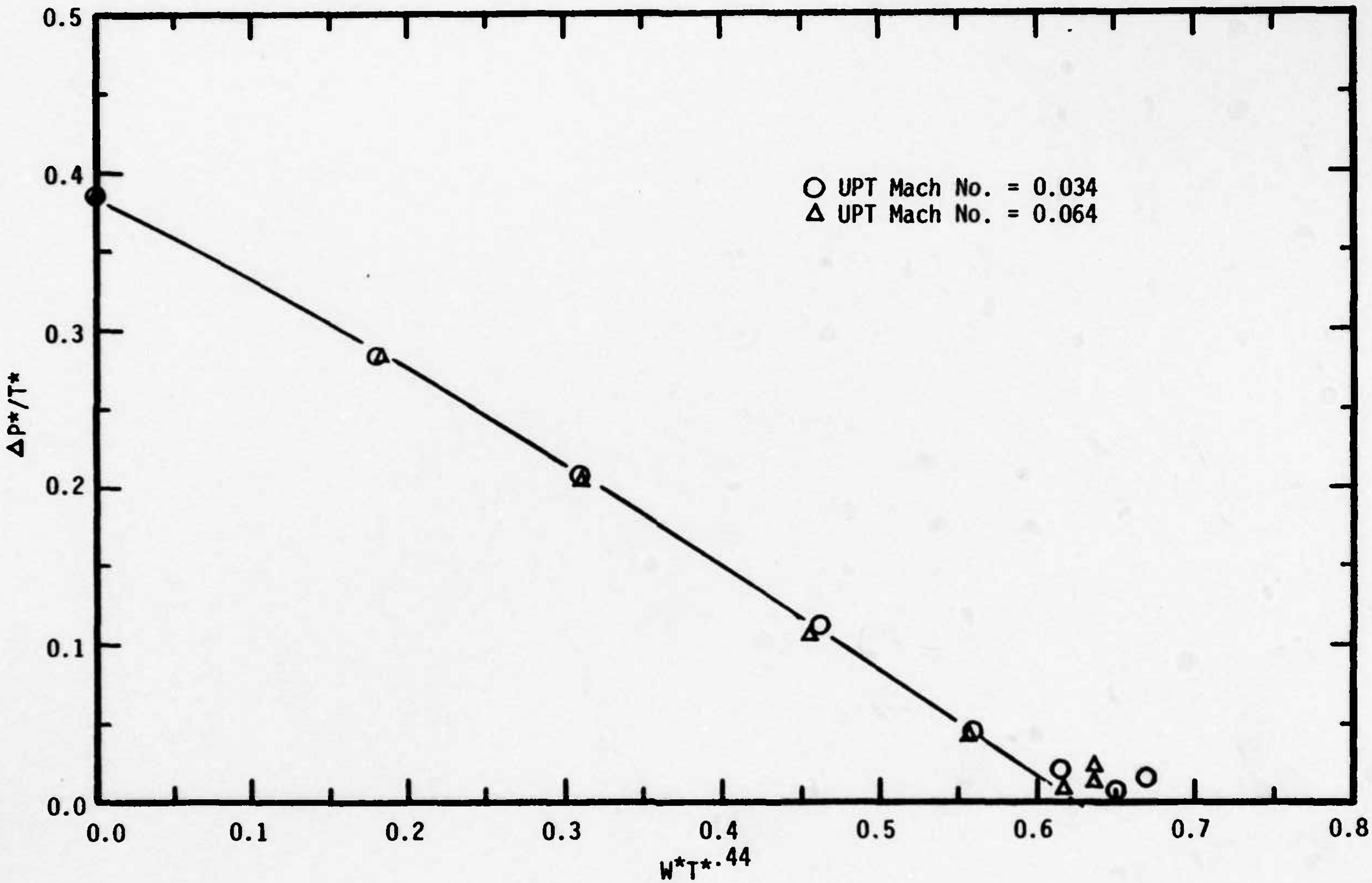
e) S/D = 1.0

FIGURE 42. Continued.



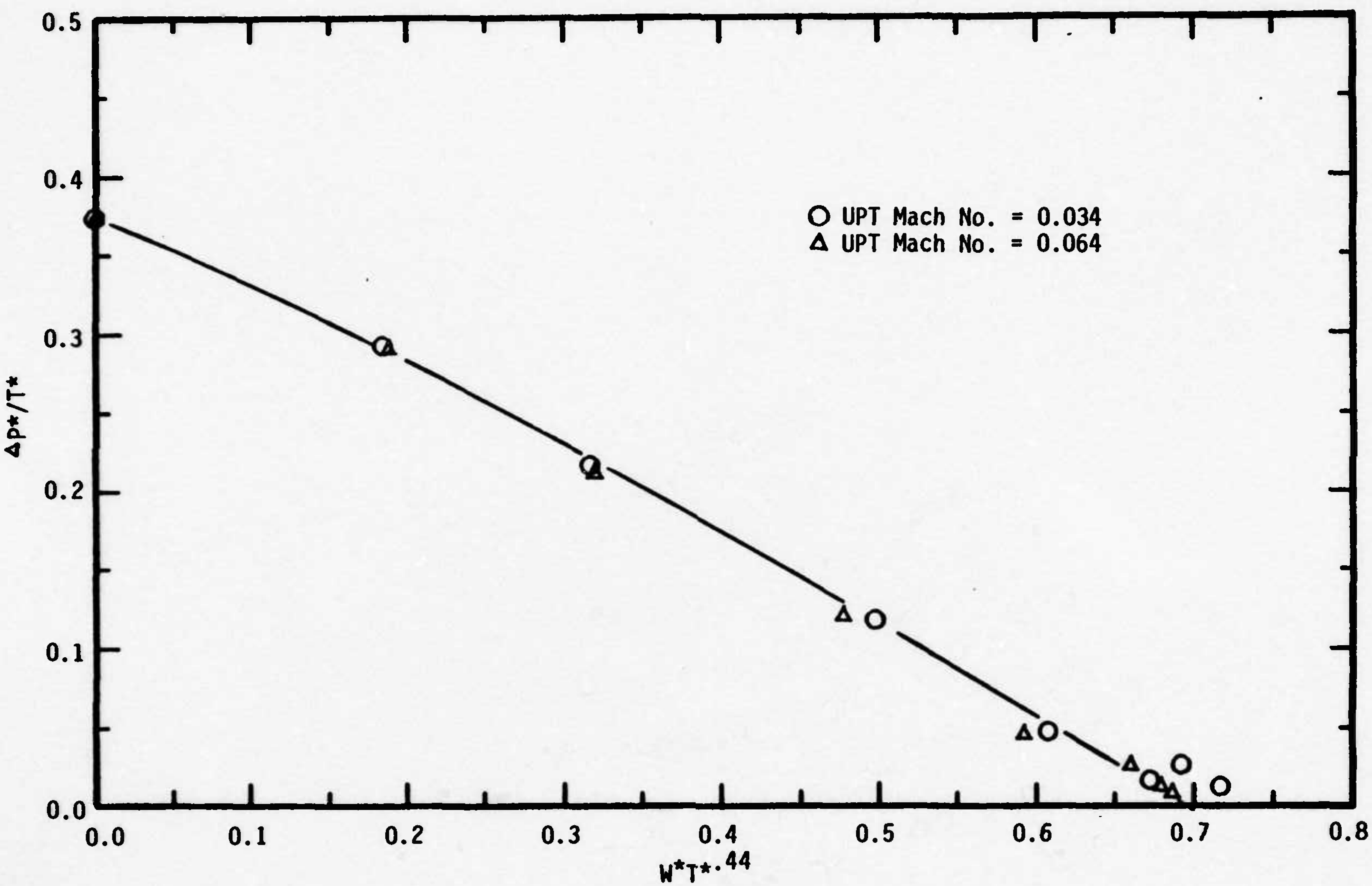
a) S/D = -0.25

FIGURE 43. Pumping Characteristic Curves for L/D = 2 with a Conical Transition



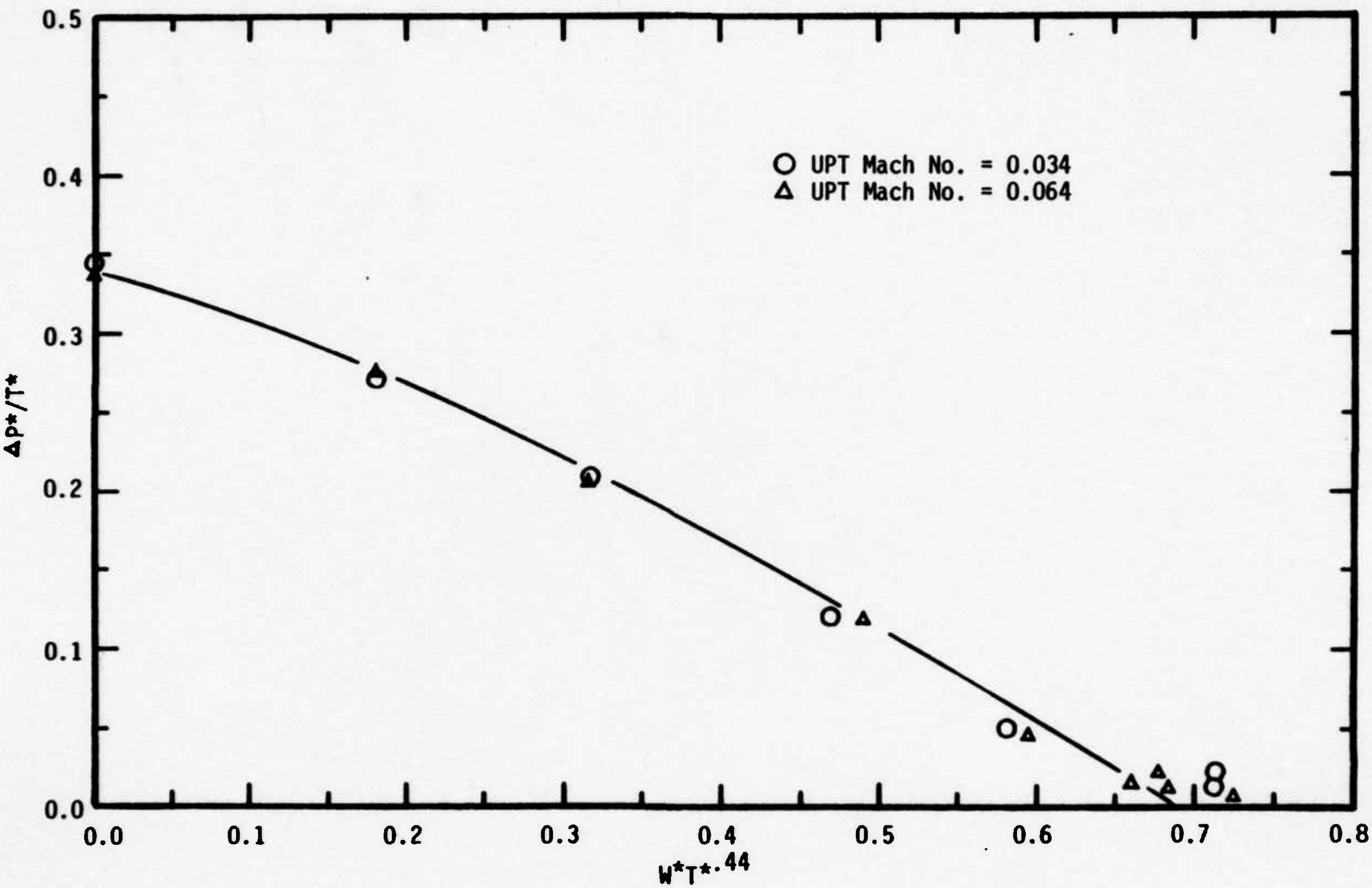
b) S/D = 0.0

FIGURE 43. Continued.



c) S/D = 0.25

FIGURE 43. Continued.



d) S/D = .5

FIGURE 43. Continued.

X. TABLES

Parameter / Performance	Pumping (based on $W^*T^{*0.44}$)	Mixing (based on K_m)
Uptake Mach Number	no effect	no effect
L/D	increased with increasing L/D from L/D= 2 to L/D= 3	improved with L/D increase from 2 to 3
S/D Standoff	increased with increasing S/D with peak values at approximately S/D= 0.5	improved with increasing S/D
Entrance Transition	Pumping was higher for $S/D \leq 0.25$ with transition. For $S/D > 0.5$ pumping with and without transition is about the same.	Mixing is better without the transition for $S/D \leq 0.5$. For $S/D > 0.5$ mixing appears to be about the same.

TABLE I. Summary of Effects of Parameters

	PUMPING COEFFICIENT			
	WITHOUT TRANSITION		WITH TRANSITION	
UPTAKE MACH NUMBERS	0.034	0.064	0.034	0.064
STANDOFF -0.25			0.585	0.585
0.0	0.55	0.55	0.625	0.625
0.25	0.68	0.68	0.690	0.690
0.50	0.715	0.715	0.690	0.640
0.75	0.71	0.71		
1.00	0.70	0.70		

a) L/D= 2.0

TABLE II. Pumping Coefficients Corresponding to Various Parameters

	PUMPING COEFFICIENT			
	WITHOUT TRANSITION		WITH TRANSITION	
UPTAKE MACH NUMBERS	0.034	0.064	0.034	0.064
STANDOFF -0.25			0.695	0.695
0.0	0.575	0.575	0.715	0.715
0.25	0.685	0.685	0.725	0.725
0.50	0.740	0.740	0.735	0.735
0.75	0.720	0.720		
1.00	0.70	0.70		

b) L/D = 3.0

TABLE II. Continued.

	MOMENTUM CORRECTION FACTOR K_m		PEAK DIVIDED BY AVERAGE VELOCITY V_x/V_{avg}	
	WITHOUT TRANSITION	WITH TRANSITION	WITHOUT TRANSITION	WITH TRANSITION
STANDOFF -0.25		1.197		1.9048
0.0	1.088	1.136	1.6753	1.7123
0.25	1.070	1.101	1.5779	1.5766
0.50	1.050	1.065	1.4658	1.4153
0.75	1.039		1.3852	
1.00	1.028		1.3116	

a) L/D= 2.0

TABLE III. Momentum Correction Factors and Peak to Average Velocity Variations for Various Parameters

	MOMENTUM CORRECTION FACTOR		PEAK DIVIDED BY AVERAGE VELOCITY V_x/V_{avg}	
	WITHOUT TRANSITION	WITH TRANSITION	WITHOUT TRANSITION	WITH TRANSITION
STANDOFF -0.25		1.053		1.4491
0.0	1.030	1.042	1.3467	1.3759
0.25	1.018	1.029	1.3380	1.2736
0.50	1.021	1.022	1.2843	1.2244
0.75	1.015		1.1874	
1.00	1.008		1.1463	

b) L/D= 3.0

TABLE III. Continued.

DATA TAKEN ON 12 AUGUST 1977 BY MIKE MOSS

CIRCUMFERENTIAL PRESSURE DISTRIBUTION FOR L/D = 3.0 AND S/D = 0.5

NUMBER OF PRIMARY NOZZLES: 4
PRIMARY NOZZLE DIAMETER: 3.38 INCHES
MIXING STACK LENGTH: 35.10 INCHES
MIXING STACK DIAMETER: 11.70 INCHES
MIXING STACK L/D: 3.000

UPTAKE DIAMETER: 11.50 INCHES
AREA RATIO, AM/AP: 3.00
ORIFICE DIAMETER: 6.902 INCHES
ORIFICE BETA: 0.497
AMBIENT PRESSURE: 29.890 INCHES HG

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION 0

X/D:	0.0	0.5	1.0	1.5	2.0	2.5
-PMS(IN. H2O):	2.400	1.000	0.680	0.330	0.150	0.050
-PMS*:	0.232	0.097	0.066	0.032	0.015	0.005

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION 1

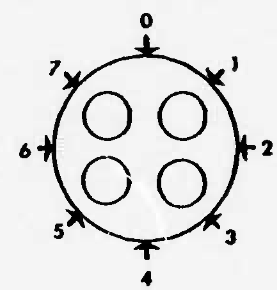
X/D:	0.0	0.5	1.0	1.5	2.0	2.5
-PMS(IN. H2O):	4.300	1.430	0.620	0.310	0.150	0.050
-PMS*:	0.416	0.138	0.060	0.030	0.015	0.005

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION 2

X/D:	0.0	0.5	1.0	1.5	2.0	2.5
-PMS(IN. H2O):	2.400	1.370	0.900	0.470	0.200	0.050
-PMS*:	0.232	0.132	0.087	0.045	0.015	0.005

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION 3

X/D:	0.0	0.5	1.0	1.5	2.0	2.5
-PMS(IN. H2O):	4.000	1.400	0.840	0.420	0.160	0.050
-PMS*:	0.387	0.135	0.081	0.041	0.015	0.005



(a) Positions 0 Through 3.

Table IV. Circumferential Pressure Distributions For Mixing Stack.

MIXING STACK PRESSURE DISTRIBUTION FOR RUN : 9 POSITION 4

X/D:	0.0	0.5	1.0	1.5	2.0	2.5
-PMS(IN. H2O):	2.300	1.200	0.800	0.400	0.170	0.050
-PMS*:	0.222	0.116	0.077	0.039	0.016	0.005

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION 5

X/D:	0.0	0.5	1.0	1.5	2.0	2.5
-PMS(IN. H2O):	4.100	1.440	0.750	0.390	0.160	0.050
-PMS*:	0.396	0.139	0.073	0.038	0.015	0.005

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION 6

X/D:	0.0	0.5	1.0	1.5	2.0	2.5
-PMS(IN. H2O):	2.000	1.300	0.900	0.450	0.180	0.050
-PMS*:	0.193	0.126	0.087	0.044	0.017	0.005

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION 7

X/D:	0.0	0.5	1.0	1.5	2.0	2.5
-PMS(IN. H2O):	4.300	1.410	0.700	0.350	0.160	0.050
-PMS*:	0.416	0.136	0.068	0.034	0.015	0.005

(b) Positions 4 Through 7.

Table IV. Continued.

DATA TAKEN ON 12 JULY 1977 BY MIKE MOSS

PRIMARY NOZZLE EXIT VELOCITIES FOR L/D = 3.0, S/D = 0.5

AMBIENT PRESSURE = 29.890 IN.HGA. TEMPERATURE = 68.0 DEG.FAHR

PRIMARY (UPTAKE) TEMPERATURE = 107.0 DEG.FAHR

NOZZLE A MACH NO. = 0.064

X	PTA	VA	VA/VAVG
INCH	IN. H2O	FT/SEC	
0.0	9.00	204.58	0.98
0.50	9.90	214.56	1.02
1.00	9.85	214.02	1.02
1.50	9.80	213.48	1.02
2.00	9.80	213.48	1.02
2.50	9.65	211.84	1.01
3.00	9.05	205.15	0.98
3.38	8.65	200.56	0.96

NOZZLE B MACH NO. = 0.064

X	PTA	VA	VA/VAVG
INCH	IN. H2O	FT/SEC	
0.0	8.90	203.44	0.96
0.50	9.65	211.84	1.00
1.00	9.70	212.39	1.01
1.50	9.80	213.48	1.01
2.00	9.84	213.91	1.01
2.50	9.84	213.91	1.01
3.00	9.84	213.91	1.01
3.38	9.20	206.84	0.98

NOZZLE C MACH NO. = 0.064

X	PTA	VA	VA/VAVG
INCH	IN. H2O	FT/SEC	
0.0	9.40	209.08	0.99
0.50	9.95	215.10	1.02
1.00	10.00	215.64	1.02
1.50	9.95	215.10	1.02
2.00	9.85	214.02	1.01
2.50	9.75	212.93	1.01
3.00	9.30	207.96	0.98
3.38	8.80	202.29	0.96

NOZZLE D MACH NO. = 0.064

X	PTA	VA	VA/VAVG
INCH	IN. H2O	FT/SEC	
0.0	8.90	203.44	0.96
0.50	9.65	211.84	1.00
1.00	9.85	214.02	1.01
1.50	9.90	214.56	1.01
2.00	9.90	214.56	1.01
2.50	9.90	214.56	1.01
3.00	9.95	215.10	1.01
3.38	9.25	207.40	0.98

(a) UPT Mach No.= 0.064

TABLE V. Primary Nozzle Exit Velocities

NOZZLE A MACH NO. = 0.034

X	PTA	VA	VA/VAVG
INCH	IN. H2O	FT/SEC	
0.0	2.30	103.42	0.94
0.50	2.75	113.08	1.03
1.00	2.75	113.08	1.03
1.50	2.75	113.08	1.03
2.00	2.75	113.08	1.03
2.50	2.70	112.05	1.02
3.00	2.61	110.17	1.00
3.38	2.35	104.54	0.95

NOZZLE B MACH NO. = 0.034

X	PTA	VA	VA/VAVG
INCH	IN. H2O	FT/SEC	
0.0	2.25	102.29	0.93
0.50	2.62	110.38	1.01
1.00	2.70	112.05	1.02
1.50	2.73	112.67	1.03
2.00	2.73	112.67	1.03
2.50	2.73	112.67	1.03
3.00	2.75	113.08	1.03
3.38	2.25	102.29	0.93

NOZZLE C MACH NO. = 0.034

X	PTA	VA	VA/VAVG
INCH	IN. H2O	FT/SEC	
0.0	2.45	106.74	0.97
0.50	2.75	113.08	1.02
1.00	2.75	113.08	1.02
1.50	2.75	113.08	1.02
2.00	2.72	112.47	1.02
2.50	2.68	111.64	1.01
3.00	2.55	108.90	0.99
3.38	2.35	104.54	0.95

NOZZLE D MACH NO. = 0.034

X	PTA	VA	VA/VAVG
INCH	IN. H2O	FT/SEC	
0.0	2.35	104.54	0.94
0.50	2.65	111.01	1.00
1.00	2.70	112.05	1.01
1.50	2.75	113.08	1.02
2.00	2.75	113.08	1.02
2.50	2.75	113.08	1.02
3.00	2.75	113.08	1.02
3.38	2.50	107.82	0.97

(b) UPT Mach No.= 0.034

TABLE V. Continued.

DATA TAKEN - 4 JUNE 1977 BY MIKE MOSS
4 NOZZLE; S/D= 0.0; L/D= 3.0

NUMBER OF PRIMARY NOZZLES: 4	UPTAKE DIAMETER: 11.50 INCHES
PRIMARY NOZZLE DIAMETER: 3.38 INCHES	AREA RATIO, AM/AP: 3.00
MIXING STACK LENGTH: 35.10 INCHES	ORIFICE DIAMETER: 6.902 INCHES
MIXING STACK DIAMETER: 11.70 INCHES	ORIFICE BETA: 0.497
MIXING STACK L/D: 3.00	AMBIENT PRESSURE: 29.93 INCHES HG

N	POR	CPOR	TOR	TUPT	TAMB	PU-PA	PA-PS	PA-PNZ	SECONDARY AREA
RUN	INCHES OF WATER		DEGREES FAHRENHEIT			INCHES OF WATER			SQUARE INCHES
1	0.7	21.5	66.0	120.0	86.0	4.80	3.80	3.80	0.0
2	0.7	22.1	66.0	120.0	86.0	5.75	2.88	2.88	12.566
3	0.7	22.0	66.0	120.0	86.0	6.20	1.94	1.94	25.133
4	0.7	22.0	67.0	120.0	86.0	6.50	1.00	1.00	50.265
5	0.7	22.0	67.0	120.0	86.0	6.80	0.35	0.35	100.531
6	0.7	22.0	66.0	120.0	86.0	6.50	0.19	0.19	150.796
7	0.7	22.0	66.0	119.0	86.0	6.50	0.11	0.11	201.062
8	0.7	22.0	66.0	119.0	86.0	6.90	0.08	0.08	248.186
9	0.7	22.0	66.0	119.0	86.0	6.90	0.01	0.01	3141.592

N	W*	P*	T*	P*/T*	W*T**.44	WP	WS	UP	UM	UW	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0	0.3707	0.9413	0.3938	0.0	3.672	0.0	217.20	72.51	75.05	0.064
2	0.1524	0.2746	0.9413	0.2917	0.1873	3.723	0.716	219.71	86.53	75.52	0.064
3	0.2165	0.1867	0.9413	0.1983	0.3082	3.714	1.175	218.70	94.66	75.57	0.064
4	0.4549	0.0960	0.9413	0.1029	0.4429	3.711	1.688	217.59	103.85	75.32	0.064
5	0.5382	0.0340	0.9413	0.0361	0.5241	3.711	1.997	217.64	109.43	75.20	0.064
6	0.5942	0.0184	0.9413	0.0196	0.5786	3.714	2.207	217.76	113.24	75.25	0.064
7	0.6029	0.0107	0.9430	0.0114	0.5875	3.714	2.239	217.34	113.79	75.10	0.064
8	0.6145	0.0073	0.9430	0.0077	0.5988	3.714	2.282	217.33	114.58	75.09	0.064
9	********	0.0010	0.9430	0.0010	********	3.714	*******	217.29	******	75.08	0.064

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION A

X/D:	0.0	0.5	1.0	1.5	2.0	2.5
-PMS(IN. H2O):	3.850	1.750	1.050	0.570	0.340	0.120
-PMS*:	0.375	0.171	0.102	0.056	0.033	0.012

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION B

X/D:	0.0	0.5	1.0	1.5	2.0	2.5
-PMS(IN. H2O):	2.600	1.600	1.150	0.600	0.270	0.080
-PMS*:	0.253	0.156	0.112	0.058	0.026	0.008

(a) S/D= 0.0; UPT Mach No.= 0.064.

Table VI. Tabulated Performance Data For L/D= 3 Without An Entrance Transition.

DATA TAKEN - 4 JUNE 1977 BY MIKE MOSS
4 NOZZLE; S/D= 0.0; L/D= 3.0

NUMBER OF PRIMARY NOZZLES: 4
PRIMARY NOZZLE DIAMETER: 3.38 INCHES
MIXING STACK LENGTH: 35.10 INCHES
MIXING STACK DIAMETER: 11.70 INCHES
MIXING STACK L/D: 3.00

UPTAKE DIAMETER: 11.50 INCHES
AREA RATIO, AM/AP: 3.00
ORIFICE DIAMETER: 6.902 INCHES
ORIFICE BETA: 0.497
AMBIENT PRESSURE: 29.91 INCHES HG

N	POR	DPOP	TCR	TUPT	TAMB	PU-PA	PA-PS	PA-PNZ	SECONDARY AREA
RUN	INCHES OF WATER		DEGREES FAHRENHEIT			INCHES OF WATER			SQUARE INCHES
1	0.2	6.1	67.0	129.0	90.0	1.40	1.10	1.10	0.0
2	0.2	6.1	67.0	129.0	90.0	1.60	0.80	0.80	12.566
3	0.2	6.1	67.0	129.0	90.0	1.70	0.55	0.55	25.133
4	0.2	6.1	67.0	129.0	90.0	1.80	0.27	0.27	50.265
5	0.2	6.1	69.0	130.0	90.0	1.90	0.10	0.10	100.531
6	0.2	6.1	69.0	130.0	90.0	1.90	0.06	0.06	150.796
7	0.2	6.1	69.0	130.0	90.0	1.90	0.04	0.04	201.062
8	0.2	6.1	69.0	130.0	90.0	1.90	0.02	0.02	248.186
9	0.2	6.1	69.0	130.0	90.0	1.95	0.0	0.0	**********

N	W*	F*	T*	P*/T*	W*T**.44	WP	WS	UF	UP	UU	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0	0.2746	0.9337	0.4012	0.0	1.954	0.0	116.71	38.96	40.23	0.034
2	0.1923	0.2729	0.9337	0.2922	0.1866	1.954	0.376	116.62	45.51	40.30	0.034
3	0.3189	0.1878	0.9337	0.2012	0.3095	1.954	0.623	116.55	50.48	40.27	0.034
4	0.4469	0.0923	0.9337	0.0989	0.4337	1.954	0.874	116.47	55.10	40.24	0.034
5	0.5450	0.0342	0.9322	0.0367	0.5284	1.951	1.063	116.40	58.59	40.22	0.034
6	0.6333	0.0205	0.9322	0.0220	0.6140	1.951	1.235	116.39	61.78	40.22	0.034
7	0.6894	0.0137	0.9322	0.0147	0.6684	1.951	1.345	116.38	63.82	40.21	0.034
8	0.6017	0.0069	0.9322	0.0073	0.5834	1.951	1.174	116.38	60.64	40.21	0.034
9	********	0.0	0.9322	0.0	********	1.951	*******	116.37	******	40.21	0.034

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION A

X/D:	0.0	0.5	1.0	1.5	2.0	2.5
-PMS(IN. H2O):	0.830	0.475	0.300	0.185	0.090	0.025
-PMS*:	0.284	0.163	0.103	0.063	0.031	0.009

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION B

X/D:	0.0	0.5	1.0	1.5	2.0	2.5
-PMS(IN. H2O):	0.650	0.450	0.320	0.200	0.090	0.025
-PMS*:	0.223	0.154	0.110	0.069	0.031	0.009

(b) S/D= 0.0; Mach No.= 0.034.

Table VI. Continued.

DATA TAKEN ON 11 JULY 1977 BY MIKE MOSS
4 NOZZLE; S/D= 0.25; L/D= 3.0

NUMBER OF PRIMARY NOZZLES: 4	UPTAKE DIAMETER: 11.50 INCHES
PRIMARY NOZZLE DIAMETER: 3.38 INCHES	AREA RATIO, AM/AP: 3.00
MIXING STACK LENGTH: 35.10 INCHES	ORIFICE DIAMETER: 6.902 INCHES
MIXING STACK DIAMETER: 11.70 INCHES	ORIFICE BETA: 0.497
MIXING STACK L/D: 3.00	AMBIENT PRESSURE: 29.52 INCHES HG

N	PCR	DPCP	TCR	TUPT	TAMB	PU-PA	PA-PS	PA-PNZ	SECONDARY AREA
RUN	INCHES OF WATER		DEGREES FAHRENHEIT			INCHES OF WATER			SQUARE INCHES
1	0.7	22.0	51.8	105.8	66.0	4.80	4.02	4.04	0.0
2	0.7	21.8	51.8	106.0	66.0	5.75	3.02	3.02	12.566
3	0.7	21.8	51.8	106.0	66.0	6.40	2.20	2.20	25.133
4	0.7	22.0	51.8	106.0	66.0	7.30	1.21	1.21	50.265
5	0.7	21.8	51.8	106.5	66.0	7.90	0.47	0.47	100.531
6	0.7	22.0	51.8	106.5	66.0	8.20	0.27	0.27	150.796
7	0.7	22.0	51.8	106.5	66.0	8.25	0.17	0.17	201.062
8	0.7	22.0	51.8	106.5	66.0	8.30	0.12	0.12	248.186
9	0.7	22.0	51.8	107.6	66.0	8.40	0.01	0.01	314159.203

N	W*	P*	T*	P*/T*	W*T**.44	WP	WS	UP	UM	UU	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0	0.3771	0.9296	0.4056	0.0	3.765	0.0	217.44	72.59	75.13	0.064
2	0.1993	0.2871	0.9293	0.3089	0.1930	3.748	0.747	215.99	85.36	74.63	0.064
3	0.3402	0.2100	0.9293	0.2260	0.3294	3.748	1.275	215.56	94.59	74.48	0.064
4	0.5024	0.1150	0.9293	0.1238	0.4864	3.765	1.891	216.01	105.67	74.64	0.064
5	0.6290	0.0452	0.9285	0.0486	0.6088	3.748	2.357	214.83	113.55	74.23	0.064
6	0.7119	0.0257	0.9285	0.0277	0.6890	3.765	2.680	215.70	119.57	74.53	0.064
7	0.7420	0.0157	0.9285	0.0169	0.7182	3.765	2.794	215.65	121.57	74.51	0.064
8	0.7811	0.0114	0.9285	0.0123	0.7560	3.765	2.941	215.62	124.17	74.51	0.064
9	********	0.0010	0.9267	0.0010	********	3.765	*******	215.98	******	74.63	0.064

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION A

X/D:	0.0	0.5	1.0	1.5	2.0	2.5
-PMS(IN. H2O):	3.650	1.650	1.100	0.630	0.270	0.070
-PMS*:	0.347	0.157	0.105	0.060	0.026	0.007

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION B

X/D:	0.0	0.5	1.0	1.5	2.0	2.5
-PMS(IN. H2O):	2.450	1.430	1.050	0.670	0.300	0.090
-PMS*:	0.233	0.136	0.100	0.064	0.029	0.009

(c) S/D= 0.25; Mach No.= 0.064

TABLE VI. Continued.

DATA TAKEN ON 11 JULY 1977 BY MIKE MOSS
4 NOZZLE; S/D= 0.25; L/D= 3.0

NUMBER OF PRIMARY NOZZLES: 4	UPTAKE DIAMETER: 11.50 INCHES
PRIMARY NOZZLE DIAMETER: 3.38 INCHES	AREA RATIO, AM/AP: 3.00
MIXING STACK LENGTH: 35.10 INCHES	ORIFICE DIAMETER: 6.902 INCHES
MIXING STACK DIAMETER: 11.70 INCHES	ORIFICE BETA: 0.497
MIXING STACK L/D: 3.00	AMBIENT PRESSURE: 29.92 INCHES HG

N RUN	PCR	DPCR	TOR	TUPT	TAMB	PU-PA	PA-PS	PA-PN2	SECONDARY AREA
	INCHES OF WATER		DEGREES FAHRENHEIT			INCHES OF WATER			SQUARE INCHES
1	0.2	6.0	54.0	116.0	73.0	1.35	1.05	1.05	0.0
2	0.2	6.0	54.0	116.0	73.0	1.60	0.78	0.78	12.566
3	0.2	6.0	54.0	116.5	73.0	1.80	0.59	0.59	25.133
4	0.2	6.0	54.0	116.5	73.0	2.00	0.35	0.35	50.265
5	0.2	6.0	54.0	116.5	73.0	2.20	0.15	0.15	100.531
6	0.2	6.0	54.0	117.0	73.0	2.25	0.09	0.09	150.796
7	0.2	6.0	54.0	117.0	73.0	2.30	0.05	0.05	201.062
8	0.2	6.0	54.0	117.0	73.0	2.30	0.04	0.04	248.186
9	0.2	6.0	54.0	117.0	73.0	2.30	0.0	0.0	**********

N RUN	W*	P*	T*	P*/T*	W*T**.44	WP LBM/SEC	WS LBM/SEC	UP FT/SEC	UM FT/SEC	UU FT/SEC	UPT MACH
1	0.0	0.3594	0.9253	0.3884	0.0	1.963	0.0	114.58	38.25	35.59	0.034
2	0.1921	0.2673	0.9253	0.2889	0.1857	1.963	0.377	114.51	45.01	35.57	0.034
3	0.3342	0.2021	0.9245	0.2186	0.3228	1.963	0.656	114.55	50.04	35.58	0.034
4	0.5147	0.1200	0.9245	0.1298	0.4973	1.963	1.010	114.48	56.39	35.56	0.034
5	0.6739	0.0515	0.9245	0.0557	0.6511	1.963	1.323	114.43	61.99	35.54	0.034
6	0.7610	0.0291	0.9237	0.0315	0.7349	1.963	1.494	114.51	65.09	35.57	0.034
7	0.8162	0.0189	0.9237	0.0204	0.7882	1.963	1.602	114.50	67.04	35.56	0.034
8	0.8592	0.0137	0.9237	0.0148	0.8297	1.963	1.687	114.50	68.55	35.56	0.034
9	********	0.0	0.9237	0.0	********	1.963	*******	114.48	******	35.56	0.034

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION A

X/D:	0.0	0.5	1.0	1.5	2.0	2.5
-PMS(IN. H2O):	0.510	0.470	0.320	0.190	0.090	0.025
-PMS*:	0.312	0.161	0.110	0.065	0.031	0.009

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION B

X/D:	0.0	0.5	1.0	1.5	2.0	2.5
-PMS(IN. H2O):	0.680	0.410	0.300	0.190	0.090	0.030
-PMS*:	0.233	0.141	0.103	0.065	0.031	0.010

(d) S/D= 0.25; UPT Mach No.= 0.034

TABLE VI. Continued.

DATA TAKEN ON 23 MAY 1977 BY MIKE MOSS
4 NOZZLE; S/D= .5; L/D= 3.0

NUMBER OF PRIMARY NOZZLES: 4	UPTAKE DIAMETER: 11.50 INCHES
PRIMARY NOZZLE DIAMETER: 3.38 INCHES	AREA RATIO, AM/AP: 3.00
MIXING STACK LENGTH: 35.10 INCHES	ORIFICE DIAMETER: 6.902 INCHES
MIXING STACK DIAMETER: 11.70 INCHES	ORIFICE BETA: 0.497
MIXING STACK L/D: 3.00	AMBIENT PRESSURE: 29.86 INCHES HG

N	POR	DPOR	TOR	TUPT	TAMB	PU-PA	PA-PS	PA-PNZ	SECONDARY AREA
RUN	INCHES OF WATER		DEGREES FAHRENHEIT			INCHES OF WATER			SQUARE INCHES
1	0.7	22.1	58.0	111.0	79.0	5.00	4.21	4.21	0.0
2	0.7	22.1	58.0	111.0	79.0	5.50	3.10	3.10	12.566
3	0.7	22.1	58.0	111.0	79.0	6.55	2.24	2.24	25.133
4	0.7	22.1	58.0	111.0	79.0	7.50	1.33	1.36	50.265
5	0.7	22.1	58.0	111.0	79.0	8.30	0.55	0.56	100.531
6	0.7	22.1	58.0	111.0	79.0	8.70	0.30	0.30	150.796
7	0.7	22.4	58.0	110.0	79.0	8.80	0.17	0.17	201.062
8	0.7	22.4	58.0	110.0	79.0	8.80	0.12	0.12	248.186
9	0.7	22.4	58.0	110.0	79.0	8.90	0.0	0.0	**********

N	W*	P*	T*	P*/T*	W*T**.44	WP	WS	UP	UM	UU	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0	0.3999	0.9439	0.4237	0.0	3.747	0.0	218.94	73.09	75.65	0.065
2	0.1993	0.2961	0.9439	0.3137	0.1943	3.747	0.747	218.34	86.50	75.45	0.064
3	0.3389	0.2149	0.9439	0.2276	0.3304	3.747	1.270	217.88	95.87	75.28	0.064
4	0.5281	0.1282	0.9439	0.1358	0.5149	3.747	1.979	217.39	108.63	75.12	0.064
5	0.6778	0.0532	0.9439	0.0564	0.6608	3.747	2.539	216.97	118.70	74.97	0.064
6	0.7441	0.0291	0.9439	0.0308	0.7254	3.747	2.788	216.83	123.19	74.92	0.064
7	0.7418	0.0163	0.9456	0.0173	0.7238	3.772	2.798	217.85	123.72	75.28	0.064
8	0.7653	0.0115	0.9456	0.0122	0.7506	3.772	2.902	217.82	125.40	75.27	0.064
9	********	0.0	0.9456	0.0	********	3.772	*******	217.76	******	75.24	0.064

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION A

X/D:	0.0	0.5	1.0	1.5	2.0	2.5
-PMS(IN. H2O):	3.900	1.550	1.020	0.550	0.250	0.070
-PMS*:	0.375	0.149	0.098	0.053	0.024	0.007

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION B

X/D:	0.0	0.5	1.0	1.5	2.0	2.5
-PMS(IN. H2O):	2.800	1.450	1.050	0.620	0.250	0.070
-PMS*:	0.269	0.139	0.101	0.060	0.024	0.007

(e) S/D= 0.50; UPT Mach No.= 0.064

TABLE VI. Continued.

DATA TAKEN ON 23 MAY 1977 BY MIKE MOSS
4 NOZZLE; S/D= .5; L/D= 3.0

NUMBER OF PRIMARY NOZZLES: 4
PRIMARY NOZZLE DIAMETER: 3.38 INCHES
MIXING STACK LENGTH; 35.10 INCHES
MIXING STACK DIAMETER: 11.70 INCHES
MIXING STACK L/D: 3.00

UPTAKE DIAMETER: 11.50 INCHES
AREA RATIO, AM/AP: 3.00
ORIFICE DIAMETER: 6.902 INCHES
ORIFICE BETA: 0.497
AMBIENT PRESSURE: 29.86 INCHES HG

N	PCR	DPOR	TOR	TUPT	TAMB	PU-PA	PA-PS	PA-PNZ	SECONDARY AREA
RUN	INCHES OF WATER		DEGREES FAHRENHEIT			INCHES OF WATER			SQUARE INCHES
1	0.2	6.1	58.0	118.0	79.0	1.40	1.18	1.22	0.0
2	0.2	6.1	58.0	121.0	79.0	1.70	0.88	0.88	12.566
3	0.2	6.1	58.0	121.0	79.0	1.90	0.64	0.64	25.133
4	0.2	6.1	58.0	121.0	79.0	2.10	0.40	0.40	50.265
5	0.2	6.1	58.0	121.0	79.0	2.30	0.16	0.16	100.531
6	0.2	6.1	58.0	119.0	79.0	2.40	0.09	0.09	150.796
7	0.2	6.1	58.0	119.0	79.0	2.40	0.05	0.05	201.062
8	0.2	6.1	58.0	119.0	79.0	2.40	0.03	0.03	248.186
9	0.2	6.1	58.0	119.0	79.0	2.45	0.0	0.0	**********

N	W*	P*	T*	P*/T*	W*T**.44	WP	WS	UP	UM	UU	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0	0.4018	0.9325	0.4309	0.0	1.970	0.0	115.64	38.60	39.56	0.034
2	0.2020	0.2570	0.9277	0.3202	0.1955	1.970	0.398	116.15	46.03	40.14	0.034
3	0.3446	0.2163	0.9277	0.2331	0.3334	1.970	0.679	116.09	51.12	40.11	0.034
4	0.5448	0.1353	0.9277	0.1459	0.5271	1.970	1.073	116.02	58.28	40.09	0.034
5	0.6783	0.0525	0.9277	0.0566	0.6562	1.970	1.336	115.95	63.05	40.06	0.034
6	0.7753	0.0307	0.9309	0.0330	0.7512	1.970	1.527	115.53	66.39	39.92	0.034
7	0.8081	0.0188	0.9309	0.0202	0.7830	1.970	1.592	115.52	67.57	39.92	0.034
8	0.7957	0.0119	0.9309	0.0128	0.7710	1.970	1.567	115.51	67.12	39.91	0.034
9	********	0.0	0.9309	0.0	********	1.970	*******	115.50	******	39.91	0.034

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION A

X/D:	0.0	0.5	1.0	1.5	2.0	2.5
-PMS(IN. H2O):	0.750	0.460	0.290	0.165	0.070	0.020
-PMS*:	0.256	0.157	0.099	0.056	0.024	0.007

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION B

X/D:	0.0	0.5	1.0	1.5	2.0	2.5
-PMS(IN. H2O):	0.710	0.410	0.290	0.170	0.070	0.020
-PMS*:	0.242	0.140	0.099	0.058	0.024	0.007

(f) S/D= 0.50; UPT Mach No.= 0.034

TABLE VI. Continued.

DATA TAKEN 6 JUNE 1977 BY MIKE MOSS
4 NOZZLE; S/D= .75; L/D= 3.0

NUMBER OF PRIMARY NOZZLES: 4
PRIMARY NOZZLE DIAMETER: 3.38 INCHES
MIXING STACK LENGTH: 35.10 INCHES
MIXING STACK DIAMETER: 11.70 INCHES
MIXING STACK L/D: 3.00

UPTAKE DIAMETER: 11.50 INCHES
AREA RATIO, AM/AP: 3.00
ORIFICE DIAMETER: 6.902 INCHES
ORIFICE BETA: 0.497
AMBIENT PRESSURE: 29.90 INCHES HG

N RUN	PCR	OPCR	TOR	TUPT	TAMB	PU-PA	PA-PS	PA-PNZ	SECONDARY AREA
	INCHES OF WATER		DEGREES FAHRENHEIT			INCHES OF WATER			SQUARE INCHES
1	0.7	22.1	54.0	107.0	69.0	4.50	3.92	3.52	0.0
2	0.7	22.1	54.0	108.0	69.0	5.80	3.00	3.00	12.566
3	0.7	22.0	54.0	108.0	69.0	6.50	2.11	2.11	25.133
4	0.7	22.0	54.0	108.0	69.0	7.40	1.21	1.21	50.265
5	0.7	22.0	54.0	108.0	69.0	8.30	0.50	0.53	100.531
6	0.7	22.0	54.0	108.0	69.0	8.50	0.25	0.26	150.796
7	1.0	22.0	54.0	108.0	69.0	8.60	0.18	0.18	201.062
8	0.7	22.0	54.0	108.0	69.0	8.70	0.11	0.11	248.186
9	0.7	22.0	54.0	108.0	69.0	8.70	0.0	0.0	**********

N RUN	W*	P*	T*	P*/T*	W*T**.44	WP LBM/SEC	WS LBM/SEC	UP FT/SEC	UM FT/SEC	UU FT/SEC	UPT MACH
1	0.0	0.3683	0.9329	0.3948	0.0	3.764	0.0	217.95	72.76	75.31	0.065
2	0.1972	0.2822	0.9313	0.3030	0.1911	3.764	0.742	217.84	85.97	75.27	0.064
3	0.3315	0.2002	0.9313	0.2150	0.3212	3.755	1.245	216.87	94.63	74.94	0.064
4	0.5020	0.1153	0.9313	0.1238	0.4865	3.755	1.885	216.39	105.91	74.77	0.064
5	0.6645	0.0478	0.9313	0.0514	0.6440	3.755	2.495	216.01	116.68	74.64	0.064
6	0.6981	0.0239	0.9313	0.0257	0.6766	3.755	2.622	215.87	118.89	74.59	0.064
7	0.7639	0.0168	0.9313	0.0180	0.7403	3.754	2.868	215.76	123.25	74.55	0.064
8	0.7473	0.0105	0.9313	0.0113	0.7243	3.755	2.807	215.80	122.17	74.57	0.064
9	********	0.0	0.9313	0.0	********	3.755	*******	215.74	******	74.55	0.064

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION A

X/D:	0.0	0.5	1.0	1.5	2.0	2.5
-PMS(IN. H2O):	2.820	1.000	0.610	0.270	0.100	0.001
-PMS*:	0.270	0.096	0.058	0.026	0.010	0.000

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION B

X/D:	0.0	0.5	1.0	1.5	2.0	2.5
-PMS(IN. H2O):	2.050	1.000	0.670	0.360	0.140	0.030
-PMS*:	0.197	0.096	0.064	0.035	0.013	0.003

(g) S/D= 0.75; UPT Mach No.= 0.064

TABLE VI. Continued.

DATA TAKEN 6 JUNE 1977 BY MIKE MOSS
4 NOZZLE; S/D= .75; L/D= 3.0

NUMBER OF PRIMARY NOZZLES: 4	UPTAKE DIAMETER: 11.50 INCHES
PRIMARY NOZZLE DIAMETER: 3.38 INCHES	AREA RATIO, AM/AP: 3.00
MIXING STACK LENGTH: 35.10 INCHES	ORIFICE DIAMETER: 6.902 INCHES
MIXING STACK DIAMETER: 11.70 INCHES	ORIFICE BETA: 0.497
MIXING STACK L/D: 3.00	AMBIENT PRESSURE: 29.93 INCHES HG

N	PCR	CPCR	TCR	TUPT	TAMB	PU-PA	PA-PS	PA-FNZ	SECONDARY AREA
RUN	INCHES OF WATER		DEGREES FAHRENHEIT			INCHES OF WATER			SQUARE INCHES
1	0.2	6.0	56.0	118.0	69.0	1.20	1.05	1.05	0.0
2	0.2	6.0	56.0	118.0	69.0	1.50	0.75	0.75	12.566
3	0.2	6.0	56.0	118.0	69.0	1.75	0.55	0.55	25.133
4	0.2	6.0	56.0	118.0	69.0	2.00	0.35	0.35	50.265
5	0.2	6.0	56.0	118.0	69.0	2.20	0.14	0.14	100.531
6	0.2	6.0	56.0	118.0	69.0	2.30	0.08	0.08	150.796
7	0.2	6.0	56.0	118.0	69.0	2.30	0.04	0.04	201.062
8	0.2	6.0	56.0	118.0	69.0	2.30	0.03	0.03	248.186
9	0.2	6.0	56.0	118.0	69.0	2.30	0.0	0.0	**********

N	W*	P*	T*	P*/T*	W*T**.44	WP	WS	UP	UM	UL	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0	0.3556	0.9152	0.3886	0.0	1.959	0.0	114.80	38.32	35.67	0.034
2	0.1894	0.2544	0.9152	0.2780	0.1822	1.959	0.371	114.71	44.92	35.64	0.034
3	0.3245	0.1867	0.9152	0.2040	0.3121	1.959	0.636	114.65	49.63	35.62	0.034
4	0.5177	0.1189	0.9152	0.1300	0.4979	1.959	1.014	114.60	56.36	35.60	0.034
5	0.6548	0.0476	0.9152	0.0520	0.6298	1.959	1.283	114.54	61.14	35.58	0.034
6	0.7425	0.0272	0.9152	0.0297	0.7141	1.959	1.454	114.52	64.20	35.57	0.034
7	0.7425	0.0153	0.9152	0.0167	0.7141	1.959	1.454	114.51	64.20	35.57	0.034
8	0.7483	0.0102	0.9152	0.0112	0.7197	1.959	1.466	114.51	64.40	35.57	0.034
9	********	0.0	0.9152	0.0	********	1.959	*******	114.50	******	35.56	0.034

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION A

X/D:	0.0	0.5	1.0	1.5	2.0	2.5
-PMS(IN. H2O):	0.670	0.330	0.170	0.070	0.020	0.001
-PMS*:	0.228	0.102	0.058	0.024	0.007	0.000

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION B

X/D:	0.0	0.5	1.0	1.5	2.0	2.5
-PMS(IN. H2O):	0.500	0.270	0.180	0.080	0.030	0.0
-PMS*:	0.170	0.092	0.061	0.027	0.010	0.0

(h) S/D= 0.75; UPT Mach No.= 0.034

TABLE VI. Continued.

DATA TAKEN ON 12 JULY 1977 BY MIKE MOSS
4 NOZZLE; S/D= 1.0; L/D= 3.0

NUMBER OF PRIMARY NOZZLES: 4
PRIMARY NOZZLE DIAMETER: 3.38 INCHES
MIXING STACK LENGTH: 35.10 INCHES
MIXING STACK DIAMETER: 11.70 INCHES
MIXING STACK L/D: 3.00

UPTAKE DIAMETER: 11.50 INCHES
AREA RATIO, AM/AP: 3.00
ORIFICE DIAMETER: 6.902 INCHES
ORIFICE BETA: 0.457
AMBIENT PRESSURE: 29.91 INCHES HG

N	FOR	DPOR	TOR	TUPT	TAMB	PU-PA	PA-PS	PA-PNZ	SECONDARY AREA
RUN	INCHES OF WATER		DEGREES FAHRENHEIT			INCHES OF WATER			SQUARE INCHES
1	0.7	22.0	53.8	107.0	68.0	4.85	4.18	4.18	0.0
2	0.7	22.0	53.8	107.0	68.0	5.50	3.20	3.20	12.566
3	0.7	22.0	53.8	107.0	68.0	6.70	2.25	2.25	25.133
4	0.7	22.2	53.8	107.0	68.0	7.50	1.30	1.30	50.265
5	0.7	22.2	53.8	107.0	68.0	8.60	0.51	0.51	100.531
6	0.7	22.2	53.8	107.0	68.0	8.80	0.33	0.33	150.796
7	0.7	22.2	53.8	107.0	68.0	8.50	0.15	0.15	201.062
8	0.7	22.0	53.8	107.0	68.0	9.00	0.10	0.10	248.186
9	0.7	22.0	53.8	107.0	68.0	9.10	0.0	0.0	**********

N	W*	P*	T*	P*/T*	W*T**.44	WP	WS	UP	UP	UU	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0	0.3931	0.9312	0.4222	0.0	3.757	0.0	217.60	72.64	75.19	0.064
2	0.2042	0.3024	0.9312	0.3248	0.1979	3.757	0.767	217.07	86.14	75.01	0.064
3	0.3425	0.2136	0.9312	0.2294	0.3320	3.757	1.287	216.56	95.23	74.83	0.064
4	0.5184	0.1229	0.9312	0.1320	0.5024	3.774	1.556	217.03	107.31	74.59	0.064
5	0.6494	0.0484	0.9312	0.0520	0.6293	3.774	2.451	216.61	115.98	74.85	0.064
6	0.7835	0.0313	0.9312	0.0337	0.7593	3.774	2.957	216.52	124.97	74.82	0.064
7	0.7043	0.0143	0.9312	0.0153	0.6826	3.774	2.658	216.42	119.61	74.78	0.064
8	0.7131	0.0096	0.9312	0.0103	0.6511	3.757	2.679	215.42	119.65	74.44	0.064
9	********	0.0	0.9312	0.0	********	3.757	*******	215.36	******	74.42	0.064

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION A

X/D:	0.0	0.5	1.0	1.5	2.0	2.5
-PMS(IN. H2O):	2.600	0.773	0.373	0.123	0.050	0.0
-PMS*:	0.250	0.074	0.036	0.012	0.005	0.0

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION B

X/D:	0.0	0.5	1.0	1.5	2.0	2.5
-PMS(IN. H2O):	1.520	0.780	0.420	0.170	0.060	0.0
-PMS*:	0.146	0.075	0.040	0.016	0.006	0.0

(i) S/D= 1.0; UPT Mach No.= 0.064

TABLE VI. Continued.

DATA TAKEN ON 1 AUGUST 1977 BY MIKE MOSS
4 NOZZLE; S/D= -.25; L/D= 3.0; WITH TRANSITION

NUMBER OF PRIMARY NOZZLES: 4
PRIMARY NOZZLE DIAMETER: 3.38 INCHES
MIXING STACK LENGTH: 35.10 INCHES
MIXING STACK DIAMETER: 11.70 INCHES
MIXING STACK L/D: 3.00

UPTAKE DIAMETER: 11.50 INCHES
AREA RATIO, AM/AP: 3.00
ORIFICE DIAMETER: 6.902 INCHES
ORIFICE BETA: 0.497
AMBIENT PRESSURE: 29.90 INCHES HG

N	PCR	OPCR	TCR	TUPT	TAMB	PU-PA	PA-PS	PA-PNZ	SECONDARY AREA
RUN	INCHES OF WATER		DEGREES FAHRENHEIT			INCHES OF WATER			SQUARE INCHES
1	0.7	22.0	60.0	114.0	75.0	4.80	3.55	3.55	0.0
2	0.7	22.0	60.0	114.0	75.0	5.90	3.05	3.05	12.566
3	0.7	22.0	60.0	114.0	75.0	6.60	2.20	2.20	25.133
4	0.7	22.0	60.0	114.0	75.0	7.35	1.25	1.25	50.265
5	0.7	22.0	60.0	114.0	75.0	8.10	0.48	0.48	100.531
6	0.7	22.0	60.0	114.0	75.0	8.20	0.27	0.27	150.796
7	0.7	22.0	60.0	114.0	75.0	8.30	0.16	0.16	201.062
8	0.7	22.0	60.0	114.0	75.0	8.45	0.12	0.12	248.186
9	0.7	22.0	60.0	114.0	75.0	8.50	0.00	0.00	**********

N	W*	P*	T*	P*/T*	W*T**.44	WP	WS	UP	US	UU	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0	0.3721	0.9320	0.3993	0.0	3.734	0.0	218.89	73.07	75.63	0.064
2	0.1993	0.2886	0.9320	0.3097	0.1532	3.734	0.744	218.40	86.35	75.47	0.064
3	0.3385	0.2091	0.9320	0.2243	0.3262	3.734	1.264	217.94	95.58	75.31	0.064
4	0.5103	0.1194	0.9320	0.1281	0.4947	3.734	1.905	217.43	107.00	75.13	0.064
5	0.6325	0.0460	0.9320	0.0494	0.6132	3.734	2.361	217.02	115.10	74.99	0.064
6	0.7115	0.0259	0.9320	0.0278	0.6858	3.734	2.657	216.90	120.39	74.95	0.064
7	0.7188	0.0149	0.9320	0.0160	0.6969	3.734	2.684	216.84	120.86	74.93	0.064
8	0.7807	0.0115	0.9320	0.0124	0.7569	3.734	2.915	216.82	125.03	74.92	0.064
9	********	0.0005	0.9320	0.0005	********	3.734	*******	216.76	******	74.93	0.064

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION A

X/D:	-1.0	-0.5	0.0	0.5	1.0	1.5
-PMS(IN. H2O):	0.650	0.440	1.100	0.760	0.460	0.270
-PMS*:	0.062	0.042	0.106	0.073	0.044	0.026

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION B

X/D:	-1.0	-0.5	0.0	0.5	1.0	1.5
-PMS(IN. H2O):	0.640	0.460	0.940	0.770	0.550	0.250
-PMS*:	0.061	0.044	0.090	0.074	0.053	0.028

(a) S/D= -0.25; UPT Mach No.= 0.064

TABLE VII. Tabulated Performance Data for L/D= 3 with an Entrance Transition

DATA TAKEN ON 1 AUGUST 1977 BY MIKE MOSS
4 NOZZLE; S/D= -.25; L/D= 3.0; WITH TRANSITION

NUMBER OF PRIMARY NOZZLES: 4
PRIMARY NOZZLE DIAMETER: 3.38 INCHES
MIXING STACK LENGTH: 35.10 INCHES
MIXING STACK DIAMETER: 11.70 INCHES
MIXING STACK L/D: 3.00

UPTAKE DIAMETER: 11.50 INCHES
AREA RATIO, AM/AP: 3.00
ORIFICE DIAMETER: 6.902 INCHES
ORIFICE BETA: 0.497
AMBIENT PRESSURE: 29.90 INCHES HG

N	POR	DPOR	TOR	TUPT	TAMB	PU-PA	PA-PS	PA-PNZ	SECONDARY AREA
RUN	INCHES OF WATER		DEGREES FAHRENHEIT			INCHES OF WATER			SQUARE INCHES
1	0.2	6.0	61.0	122.5	75.0	1.30	1.07	1.07	0.0
2	0.2	6.0	61.0	122.5	75.0	1.60	0.82	0.82	12.566
3	0.2	6.0	61.0	122.5	75.0	1.80	0.61	0.61	25.133
4	0.2	6.0	61.0	122.5	75.0	2.00	0.35	0.35	50.265
5	0.2	6.0	61.0	122.5	75.0	2.20	0.13	0.13	100.531
6	0.2	6.0	61.0	122.5	75.0	2.30	0.08	0.08	150.796
7	0.2	6.0	61.0	122.5	75.0	2.30	0.05	0.05	201.062
8	0.2	6.0	61.0	122.5	75.0	2.30	0.04	0.04	248.186
9	0.2	6.0	61.0	122.5	75.0	2.30	0.0	0.0	**********

N	W*	P*	T*	P*/T*	W*T**.44	WP	WS	UP	UM	UU	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0	0.3643	0.9184	0.3967	0.0	1.949	0.0	115.14	38.44	39.78	0.034
2	0.1979	0.2796	0.9184	0.3044	0.1907	1.949	0.386	115.07	45.38	39.76	0.034
3	0.3414	0.2082	0.9184	0.2267	0.3289	1.949	0.666	115.01	50.41	39.74	0.034
4	0.5173	0.1196	0.9184	0.1302	0.4982	1.949	1.008	114.93	56.58	39.71	0.034
5	0.6305	0.0445	0.9184	0.0484	0.6073	1.949	1.229	114.87	60.54	39.69	0.034
6	0.7183	0.0257	0.9184	0.0279	0.6519	1.949	1.400	114.86	63.63	39.69	0.034
7	0.8202	0.0188	0.9184	0.0205	0.7900	1.949	1.599	114.85	67.22	39.69	0.034
8	0.8634	0.0137	0.9184	0.0149	0.8317	1.949	1.683	114.85	68.74	39.68	0.034
9	********	0.0	0.9184	0.0	********	1.949	*******	114.83	******	39.68	0.034

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION A

X/D:	-1.0	-0.5	0.0	0.5	1.0	1.5
-PMS(IN. H2O):	0.160	0.110	0.290	0.190	0.110	0.050
-PMS*:	0.055	0.038	0.099	0.065	0.038	0.017

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION B

X/D:	-1.0	-0.5	0.0	0.5	1.0	1.5
-PMS(IN. H2O):	0.170	0.120	0.250	0.200	0.140	0.070
-PMS*:	0.058	0.041	0.086	0.068	0.048	0.024

(b) S/D= -0.25; UPT Mach No.= 0.034

TABLE VII. Continued.

DATA TAKEN ON 30 JULY 1977 BY MIKE MOSS
4 NOZZLE; S/D=0.0; L/D=3.0; WITH TRANSITION

NUMBER OF PRIMARY NOZZLES: 4	UPTAKE DIAMETER: 11.50 INCHES
PRIMARY NOZZLE DIAMETER: 3.38 INCHES	AREA RATIO, AM/AP: 3.00
MIXING STACK LENGTH: 35.10 INCHES	ORIFICE DIAMETER: 6.902 INCHES
MIXING STACK DIAMETER: 11.70 INCHES	ORIFICE BETA: 0.497
MIXING STACK L/D: 3.00	AMBIENT PRESSURE: 29.88 INCHES HG

N	FCR	CPOR	TCR	TUPT	TAMB	PU-PA	PA-PS	PA-PN2	SECONDARY AREA
RUN	INCHES OF WATER		DEGREES FAHRENHEIT			INCHES OF WATER			SQUARE INCHES
1	0.7	22.0	72.0	125.0	88.0	4.90	4.00	4.00	0.0
2	0.7	22.0	72.0	125.0	88.0	5.90	3.12	3.12	12.566
3	0.7	22.0	72.0	125.6	88.0	6.50	2.23	2.23	25.133
4	0.7	22.0	72.0	125.6	88.0	7.50	1.30	1.33	50.265
5	0.7	22.0	72.0	125.6	88.0	8.20	0.52	0.52	100.531
6	0.7	22.0	72.0	125.6	88.0	8.40	0.30	0.30	150.796
7	0.7	22.0	72.0	125.6	88.0	8.50	0.17	0.17	201.062
8	0.7	22.0	72.0	125.6	88.0	8.50	0.12	0.12	248.186
9	0.7	22.0	72.0	128.5	88.0	8.70	0.05	0.05	**********

N	W*	P*	T*	P*/T*	W*T**.44	WP	WS	UP	UM	UL	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0	0.3801	0.9367	0.4058	0.0	3.690	0.0	220.65	73.66	76.24	0.064
2	0.2014	0.2978	0.9367	0.3179	0.1957	3.690	0.743	220.17	87.26	76.08	0.064
3	0.3406	0.2133	0.9358	0.2280	0.3308	3.690	1.257	219.91	96.68	75.59	0.064
4	0.5261	0.1249	0.9358	0.1335	0.5109	3.690	1.941	219.40	109.18	75.81	0.064
5	0.6579	0.0502	0.9358	0.0536	0.6390	3.690	2.428	218.98	118.05	75.67	0.064
6	0.7496	0.0290	0.9358	0.0310	0.7280	3.690	2.766	218.86	124.27	75.63	0.064
7	0.7412	0.0159	0.9358	0.0170	0.7199	3.690	2.735	218.79	123.68	75.60	0.064
8	0.7638	0.0111	0.9358	0.0119	0.7418	3.690	2.818	218.76	125.21	75.59	0.064
9	********	0.0048	0.9311	0.0051	********	3.690	*******	219.81	******	75.55	0.064

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION A

X/D:	-1.0	-0.5	0.0	0.5	1.0	1.5
-PMS(IN. H2O):	0.520	0.370	0.970	0.700	0.420	0.230
-PMS*:	0.050	0.035	0.093	0.067	0.040	0.022

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION B

X/D:	-1.0	-0.5	0.0	0.5	1.0	1.5
-PMS(IN. H2O):	0.500	0.380	0.860	0.700	0.480	0.250
-PMS*:	0.048	0.036	0.082	0.067	0.046	0.024

(c) S/D= 0.0; UPT Mach No.= 0.064

TABLE VII. Continued.

DATA TAKEN ON 30 JULY 1977 BY MIKE MOSS

4 NOZZLE; S/D=0.0; L/D=3.0; WITH TRANSITION

NUMBER OF PRIMARY NOZZLES: 4	UPTAKE DIAMETER: 11.50 INCHES
PRIMARY NOZZLE DIAMETER: 3.38 INCHES	AREA RATIO, AM/AP: 3.00
MIXING STACK LENGTH: 35.10 INCHES	ORIFICE DIAMETER: 6.902 INCHES
MIXING STACK DIAMETER: 11.70 INCHES	ORIFICE BETA: 0.497
MIXING STACK L/D: 3.00	AMBIENT PRESSURE: 29.88 INCHES HG

N	PCR	OPCR	TCR	TUPT	TAMB	PU-PA	PA-PS	PA-PNZ	SECONDARY AREA
RUN	INCHES OF WATER		DEGREES FAHRENHEIT			INCHES OF WATER			SQUARE INCHES
1	0.2	6.0	74.0	134.5	88.0	1.35	1.05	1.05	0.0
2	0.2	6.0	74.0	134.5	88.0	1.60	0.81	0.81	12.566
3	0.2	6.0	74.0	134.5	88.0	1.80	0.60	0.60	25.133
4	0.2	6.0	74.0	135.0	88.0	2.00	0.35	0.36	50.265
5	0.2	6.0	74.0	135.0	88.0	2.20	0.15	0.15	100.531
6	0.2	6.0	74.0	135.0	88.0	2.30	0.08	0.08	150.796
7	0.2	6.0	74.0	135.0	88.0	2.30	0.04	0.04	201.062
8	0.2	6.0	74.0	135.0	88.0	2.30	0.03	0.03	248.186
9	0.2	6.0	74.0	135.0	88.0	2.35	0.0	0.0	**********

N	W*	P*	T*	P*/T*	W*T**.44	WP	WS	UP	UM	UU	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0	0.3604	0.9217	0.3910	0.0	1.925	0.0	116.10	38.76	40.12	0.034
2	0.1568	0.2783	0.9217	0.3020	0.1899	1.925	0.379	116.04	45.75	40.05	0.034
3	0.2387	0.2064	0.9217	0.2239	0.3268	1.925	0.652	115.98	50.19	40.07	0.034
4	0.5248	0.1203	0.9210	0.1307	0.5061	1.925	1.010	116.00	57.42	40.08	0.034
5	0.6775	0.0516	0.9210	0.0561	0.6534	1.925	1.304	115.94	62.85	40.06	0.034
6	0.7186	0.0258	0.9210	0.0280	0.6930	1.925	1.383	115.92	64.30	40.06	0.034
7	0.7421	0.0155	0.9210	0.0168	0.7157	1.925	1.428	115.91	65.14	40.05	0.034
8	0.7480	0.0103	0.9210	0.0112	0.7214	1.925	1.440	115.91	65.35	40.05	0.034
9	********	0.0	0.9210	0.0	********	1.925	*******	115.90	******	40.05	0.034

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION A

X/D:	-1.0	-0.5	0.0	0.5	1.0	1.5
-PMS(IN. H2O):	0.130	0.100	0.250	0.180	0.100	0.050
-PMS*:	0.045	0.034	0.086	0.062	0.034	0.017

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION B

X/D:	-1.0	-0.5	0.0	0.5	1.0	1.5
-PMS(IN. H2O):	0.130	0.100	0.230	0.190	0.120	0.060
-PMS*:	0.045	0.034	0.079	0.065	0.041	0.021

(d) S/D= 0.0; UPT Mach No.= 0.034

TABLE VII. Continued.

DATA TAKEN ON 1 AUGUST 1977 BY MIKE MOSS

4 NOZZLE; S/D= .25; L/D= 3.0; WITH TRANSITION

NUMBER OF PRIMARY NOZZLES: 4
PRIMARY NOZZLE DIAMETER: 3.38 INCHES
MIXING STACK LENGTH: 35.10 INCHES
MIXING STACK DIAMETER: 11.70 INCHES
MIXING STACK L/D: 3.00

UPTAKE DIAMETER: 11.50 INCHES
AREA RATIO, AM/AP: 3.00
ORIFICE DIAMETER: 6.902 INCHES
ORIFICE BETA: 0.497
AMBIENT PRESSURE: 29.91 INCHES HG

N	PCR	DPCR	TCR	TUPT	TAMB	PU-PA	PA-PS	PA-PNZ	SECONDARY AREA
RUN	INCHES OF WATER		DEGREES FAHRENHEIT			INCHES OF WATER			SQUARE INCHES
1	0.7	22.0	59.0	111.5	70.0	5.20	3.68	3.68	0.0
2	0.7	22.0	59.0	111.5	70.0	5.90	2.94	2.94	12.566
3	0.7	22.0	59.0	111.5	70.0	6.70	2.20	2.20	25.133
4	0.7	22.0	59.0	111.5	70.0	7.50	1.25	1.25	50.265
5	0.7	22.0	59.0	111.5	70.0	8.40	0.50	0.50	100.531
6	0.7	22.0	59.0	111.5	70.0	8.60	0.28	0.29	150.796
7	0.7	22.0	59.0	111.5	70.0	8.70	0.16	0.16	201.062
8	0.7	22.0	59.0	111.5	70.0	8.80	0.11	0.11	248.186
9	0.7	22.0	59.0	111.5	70.0	8.90	0.00	0.00	**********

N	W*	P*	T*	P*/T*	W*T**.44	WP	WS	UP	UM	UL	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0	0.3463	0.9273	0.3734	0.0	3.738	0.0	217.96	72.76	75.31	0.064
2	0.1564	0.2777	0.9273	0.2994	0.1500	3.738	0.734	217.56	85.76	75.18	0.064
3	0.3358	0.2085	0.9273	0.2249	0.3287	3.738	1.270	217.16	95.21	75.04	0.064
4	0.5122	0.1190	0.9273	0.1284	0.4955	3.738	1.915	216.65	106.57	74.86	0.064
5	0.6479	0.0478	0.9273	0.0515	0.6268	3.738	2.422	216.25	115.51	74.72	0.064
6	0.7402	0.0268	0.9273	0.0289	0.7160	3.738	2.767	216.14	121.64	74.68	0.064
7	0.7330	0.0153	0.9273	0.0165	0.7091	3.738	2.740	216.07	121.14	74.66	0.064
8	0.7330	0.0101	0.9273	0.0108	0.7091	3.738	2.740	216.04	121.13	74.65	0.064
9	********	0.0005	0.9273	0.0005	********	3.738	*******	215.99	******	74.63	0.064

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION A

X/D:	-1.0	-0.5	0.0	0.5	1.0	1.5
-PMS(IN. H2O):	0.400	0.300	0.940	0.600	0.340	0.210
-PMS*:	0.038	0.029	0.090	0.057	0.033	0.020

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION B

X/D:	-1.0	-0.5	0.0	0.5	1.0	1.5
-PMS(IN. H2O):	0.400	0.300	0.820	0.600	0.350	0.210
-PMS*:	0.038	0.029	0.079	0.057	0.037	0.020

(e) S/D= 0.25; UPT Mach No.= 0.064

TABLE VII. Continued.

DATA TAKEN ON 1 AUGUST 1977 BY MIKE MOSS
4 NOZZLE; S/D= .25; L/D= 3.0; WITH TRANSITION

NUMBER OF PRIMARY NOZZLES: 4
PRIMARY NOZZLE DIAMETER: 3.38 INCHES
MIXING STACK LENGTH: 35.10 INCHES
MIXING STACK DIAMETER: 11.70 INCHES
MIXING STACK L/D: 3.00

UPTAKE DIAMETER: 11.50 INCHES
AREA RATIO, AM/AP: 3.00
ORIFICE DIAMETER: 6.902 INCHES
ORIFICE BETA: 0.497
AMBIENT PRESSURE: 29.51 INCHES HG

N	PCR	CPCR	TCR	TUPT	TAMB	PU-PA	PA-PS	PA-PNZ	SECONDARY AREA
RUN	INCHES OF WATER		DEGREES FAHRENHEIT			INCHES OF WATER			SQUARE INCHES
1	0.2	6.0	60.0	120.0	70.0	1.40	1.00	1.00	0.0
2	0.2	6.0	60.0	120.0	70.0	1.70	0.75	0.75	12.566
3	0.2	6.0	60.0	120.0	70.0	1.90	0.60	0.60	25.133
4	0.2	6.0	60.0	120.0	70.0	2.10	0.35	0.35	50.265
5	0.2	6.0	60.0	120.0	70.0	2.30	0.14	0.14	100.531
6	0.2	6.0	60.0	120.0	70.0	2.40	0.08	0.08	150.796
7	0.2	6.0	60.0	120.0	70.0	2.40	0.05	0.05	201.062
8	0.2	6.0	60.0	120.0	70.0	2.40	0.04	0.04	248.186
9	0.2	6.0	60.0	120.0	70.0	2.40	0.00	0.00	**********

N	W*	P*	T*	P*/T*	W*T**.44	WP	WS	UP	UM	UU	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0	0.3357	0.9137	0.3718	0.0	1.951	0.0	114.71	38.29	35.64	0.034
2	0.1950	0.2686	0.9137	0.2940	0.1874	1.951	0.361	114.66	45.08	35.62	0.034
3	0.3399	0.2042	0.9137	0.2235	0.3267	1.951	0.663	114.60	50.12	35.60	0.034
4	0.5192	0.1193	0.9137	0.1305	0.4990	1.951	1.013	114.53	56.36	35.58	0.034
5	0.6567	0.0478	0.9137	0.0523	0.6312	1.951	1.282	114.47	61.14	35.55	0.034
6	0.7447	0.0273	0.9137	0.0299	0.7157	1.951	1.453	114.46	64.20	35.55	0.034
7	0.8233	0.0171	0.9137	0.0187	0.7912	1.951	1.606	114.45	66.94	35.55	0.034
8	0.8666	0.0137	0.9137	0.0149	0.8329	1.951	1.691	114.44	68.45	35.54	0.034
9	********	0.0017	0.9137	0.0019	********	1.951	*******	114.43	******	35.54	0.034

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION A

X/D:	-1.0	-0.5	0.0	0.5	1.0	1.5
-PMS(IN. H2O):	0.120	0.090	0.270	0.160	0.090	0.050
-PMS*:	0.041	0.031	0.092	0.055	0.031	0.017

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION 9

X/D:	-1.0	-0.5	0.0	0.5	1.0	1.5
-PMS(IN. H2O):	0.110	0.090	0.220	0.170	0.100	0.050
-PMS*:	0.038	0.031	0.075	0.058	0.034	0.017

(f) S/D= 0.025; UPT Mach No.= 0.034

TABLE VII. Continued.

DATA TAKEN ON 2 AUGUST 1977 BY MIKE MOSS
4 NOZZLE; S/D=.5; L/D=3.0; WITH TRANSITION

NUMBER OF PRIMARY NOZZLES: 4
PRIMARY NOZZLE DIAMETER: 3.38 INCHES
MIXING STACK LENGTH: 35.10 INCHES
MIXING STACK DIAMETER: 11.70 INCHES
MIXING STACK L/D: 3.00

UPTAKE DIAMETER: 11.50 INCHES
AREA RATIO, AM/AP: 3.00
ORIFICE DIAMETER: 6.902 INCHES
ORIFICE BETA: 0.497
AMBIENT PRESSURE: 29.93 INCHES HG

N	POR	DPOR	TOR	TUPT	TAMB	PU-PA	PA-PS	PA-PN2	SECONDARY AREA
RUN	INCHES OF WATER		DEGREES FAHRENHEIT			INCHES OF WATER			SQUARE INCHES
1	0.7	22.0	60.9	116.6	88.0	5.60	3.52	3.52	0.0
2	0.7	22.0	60.8	116.6	88.0	6.20	2.85	2.85	12.566
3	0.7	22.0	60.8	116.6	88.0	6.80	2.12	2.12	25.133
4	0.7	22.0	60.8	116.6	88.0	7.10	1.22	1.22	50.265
5	0.7	22.0	60.8	116.6	88.0	8.40	0.50	0.50	100.531
6	0.7	22.0	60.8	116.6	88.0	8.70	0.28	0.25	150.796
7	0.7	22.0	60.8	116.6	88.0	8.80	0.17	0.17	201.062
8	0.7	22.0	60.8	116.6	88.0	8.80	0.11	0.11	248.186
9	0.7	22.0	66.2	115.0	88.0	9.00	0.00	0.00	**********

N	W*	P*	T*	P*/T*	W*T**.44	WP	WS	UP	UM	UU	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0	0.2379	0.9504	0.3556	0.0	3.732	0.0	219.35	73.22	75.79	0.064
2	0.1905	0.2745	0.9504	0.2888	0.1863	3.733	0.711	219.00	86.25	75.67	0.064
3	0.3286	0.2049	0.9504	0.2156	0.3213	3.733	1.226	218.60	95.65	75.54	0.064
4	0.4985	0.1184	0.9504	0.1246	0.4875	3.733	1.861	218.12	107.21	75.37	0.064
5	0.6383	0.0487	0.9504	0.0513	0.6241	3.733	2.383	217.73	116.72	75.24	0.064
6	0.7292	0.0273	0.9504	0.0287	0.7130	3.733	2.722	217.62	122.95	75.19	0.064
7	0.7444	0.0166	0.9504	0.0175	0.7279	3.733	2.778	217.56	123.98	75.17	0.064
8	0.7391	0.0107	0.9504	0.0113	0.7227	3.733	2.759	217.52	123.61	75.16	0.064
9	********	0.0005	0.9464	0.0005	********	3.713	*******	217.25	******	75.07	0.064

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION A

X/D:	-1.0	-0.5	0.0	0.5	1.0	1.5
-PMS(IN. H2O):	0.330	0.240	0.800	0.480	0.230	0.160
-PMS*:	0.032	0.023	0.078	0.047	0.023	0.016

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION B

X/D:	-1.0	-0.5	0.0	0.5	1.0	1.5
-PMS(IN. H2O):	0.300	0.220	0.750	0.510	0.290	0.170
-PMS*:	0.029	0.022	0.073	0.050	0.028	0.017

(g) S/D= 0.50; UPT Mach No.= 0.064

TABLE VII. Continued.

DATA TAKEN ON 2 AUGUST 1977 BY MIKE MOSS
4 NOZZLE; S/D=.5; L/D=3.0; WITH TRANSITION

NUMBER OF PRIMARY NOZZLES: 4
PRIMARY NOZZLE DIAMETER: 3.38 INCHES
MIXING STACK LENGTH: 35.10 INCHES
MIXING STACK DIAMETER: 11.70 INCHES
MIXING STACK L/D: 3.00

UPTAKE DIAMETER: 11.50 INCHES
AREA RATIO, AM/AP: 3.00
ORIFICE DIAMETER: 6.902 INCHES
ORIFICE BETA: 0.497
AMBIENT PRESSURE: 29.93 INCHES HG

N	PCR	CPCP	TCR	TUPI	TAMB	PU-PA	PA-PS	PA-PNZ	SECONDARY AREA
RUN	INCHES OF WATER		DEGREES FAHRENHEIT			INCHES OF WATER			SQUARE INCHES
1	0.2	6.0	64.4	128.0	88.0	1.50	0.95	0.95	0.0
2	0.2	6.0	64.4	128.0	88.0	1.70	0.76	0.76	12.566
3	0.2	6.0	64.4	128.0	88.0	1.90	0.60	0.60	25.133
4	0.2	6.0	64.4	128.0	88.0	2.15	0.36	0.36	50.265
5	0.2	6.0	64.4	128.0	88.0	2.35	0.15	0.15	100.531
6	0.2	6.0	64.4	128.0	88.0	2.40	0.08	0.08	150.796
7	0.2	6.0	64.4	128.0	88.0	2.45	0.05	0.05	201.062
8	0.2	6.0	64.4	128.0	88.0	2.50	0.04	0.04	248.186
9	0.2	6.0	68.0	129.0	88.0	2.50	0.0	0.0	**********

N	W*	P*	T*	P*/T*	W*T**.44	WP	WS	UP	US	UU	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0	0.3275	0.9319	0.3514	0.0	1.944	0.0	115.76	38.64	40.00	0.034
2	0.1889	0.2622	0.9319	0.2814	0.1831	1.944	0.367	115.70	45.41	39.98	0.034
3	0.3357	0.2072	0.9319	0.2223	0.3254	1.944	0.652	115.66	50.67	39.96	0.034
4	0.5200	0.1245	0.9319	0.1336	0.5041	1.944	1.011	115.59	57.27	39.94	0.034
5	0.6713	0.0519	0.9319	0.0557	0.6508	1.944	1.305	115.53	62.69	39.92	0.034
6	0.7354	0.0277	0.9319	0.0297	0.7130	1.944	1.430	115.51	64.98	39.91	0.034
7	0.8130	0.0190	0.9319	0.0204	0.7882	1.944	1.580	115.50	67.77	39.91	0.034
8	0.8559	0.0139	0.9319	0.0149	0.8257	1.944	1.664	115.50	69.31	39.91	0.034
9	********	0.0	0.9304	0.0	********	1.927	*******	115.29	******	39.84	0.033

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION A

X/D:	-1.0	-0.5	0.0	0.5	1.0	1.5
-PMS(IN. H2O):	0.105	0.075	0.240	0.130	0.060	0.035
-PMS*:	0.036	0.026	0.083	0.045	0.021	0.012

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION B

X/D:	-1.0	-0.5	0.0	0.5	1.0	1.5
-PMS(IN. H2O):	0.090	0.070	0.215	0.140	0.070	0.040
-PMS*:	0.031	0.024	0.075	0.049	0.024	0.014

(h) S/D= 0.50; UPT Mach No.= 0.034

TABLE VII. Continued.

DATA TAKEN ON 19 JULY 1977 BY MIKE MOSS

4 NOZZLE; S/D= 0.00; L/D= 2.0

NUMBER OF PRIMARY NOZZLES: 4	UPTAKE DIAMETER: 11.50 INCHES
PRIMARY NOZZLE DIAMETER: 3.38 INCHES	AREA RATIO, AM/AP: 3.00
MIXING STACK LENGTH: 23.40 INCHES	ORIFICE DIAMETER: 6.932 INCHES
MIXING STACK DIAMETER: 11.70 INCHES	ORIFICE BETA: 0.497
MIXING STACK L/D: 2.00	AMBIENT PRESSURE: 29.93 INCHES HG

N	FCR	DPCR	TCR	TUPT	TAMB	PU-PA	PA-PS	PA-PN2	SECONDARY AREA
RUN	INCHES OF WATER		DEGREES FAHRENHEIT			INCHES OF WATER			SQUARE INCHES
1	0.7	22.0	68.0	123.0	85.0	5.10	4.00	4.00	0.0
2	0.7	22.0	68.0	123.0	85.0	6.10	2.84	2.84	12.566
3	0.7	22.0	68.0	123.0	85.0	6.50	1.84	1.84	25.133
4	0.7	22.0	68.0	123.0	85.0	7.00	0.91	0.51	50.265
5	0.7	22.0	68.0	123.0	85.0	7.20	0.34	0.34	100.531
6	0.7	22.0	68.0	123.0	85.0	7.30	0.18	0.18	150.796
7	0.7	22.0	68.0	123.0	85.0	7.30	0.11	0.11	201.062
8	0.7	22.0	68.0	123.0	85.0	7.35	0.08	0.08	248.186
9	0.7	22.0	68.0	123.0	85.0	7.35	0.05	0.05	**********

N	W*	P*	T*	P*/T*	WPT**.44	WP	WS	UP	UM	UU	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0	0.2778	0.9348	0.4041	0.0	3.707	0.0	220.54	73.62	76.21	0.064
2	0.1520	0.2658	0.9348	0.2886	0.1864	3.707	0.712	219.91	86.49	75.99	0.064
3	0.3091	0.1757	0.9348	0.1879	0.3000	3.707	1.146	219.36	94.29	75.80	0.064
4	0.4347	0.0873	0.9348	0.0934	0.4220	3.707	1.612	218.86	102.69	75.63	0.064
5	0.5314	0.0327	0.9348	0.0350	0.5159	3.707	1.970	218.56	109.17	75.52	0.064
6	0.5800	0.0173	0.9348	0.0185	0.5631	3.707	2.150	218.47	112.46	75.49	0.064
7	0.6046	0.0106	0.9348	0.0113	0.5869	3.707	2.241	218.43	114.12	75.48	0.064
8	0.6162	0.0072	0.9348	0.0077	0.5982	3.707	2.284	218.41	114.90	75.47	0.064
9	*********	0.0048	0.9348	0.0052	*********	3.707	*******	218.40	******	75.47	0.064

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION A

X/D:	0.0	0.5	1.0	1.5
-PMS(IN. H2O):	3.440	1.520	0.850	0.400
-PMS*:	0.331	0.146	0.082	0.039

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION B

X/D:	0.0	0.5	1.0	1.5
-PMS(IN. H2O):	2.300	1.400	0.950	0.420
-PMS*:	0.222	0.135	0.091	0.040

(a) S/D= 0.0; UPT Mach No.= 0.064

TABLE VIII. Tabulated Performance Data for L/D= 2 Without an Entrance Transition

DATA TAKEN ON 19 JULY 1977 BY MIKE MOSS
4 NOZZLE: S/D= 0.00; L/D= 2.0

NUMBER OF PRIMARY NOZZLES: 4
PRIMARY NOZZLE DIAMETER: 3.38 INCHES
MIXING STACK LENGTH: 23.40 INCHES
MIXING STACK DIAMETER: 11.70 INCHES
MIXING STACK L/D: 2.00

UPTAKE DIAMETER: 11.50 INCHES
AREA RATIO, AM/AP: 3.00
ORIFICE DIAMETER: 6.902 INCHES
ORIFICE BETA: 0.497
AMBIENT PRESSURE: 29.92 INCHES HG

N	PCR	DPCR	TOR	TUPT	TAMB	PU-PA	PA-PS	PA-PNZ	SECONDARY AREA
RUN	INCHES OF WATER		DEGREES FAHRENHEIT			INCHES OF WATER			SQUARE INCHES
1	0.2	6.0	73.0	134.0	89.0	1.30	0.56	0.56	0.0
2	0.2	6.0	73.0	134.0	89.0	1.50	0.68	0.68	12.566
3	0.2	6.0	73.0	134.0	89.0	1.65	0.44	0.44	25.133
4	0.2	6.0	73.0	134.5	89.0	1.80	0.25	0.25	53.265
5	0.2	6.0	73.0	134.5	89.0	1.85	0.10	0.10	100.531
6	0.2	6.0	73.0	134.5	89.0	1.85	0.05	0.05	150.796
7	0.2	6.0	73.0	134.5	89.0	1.90	0.03	0.03	201.062
8	0.2	6.0	73.0	134.5	89.0	1.90	0.03	0.03	248.186
9	0.2	6.0	73.0	134.5	89.0	1.90	0.0	0.0	**********

N	W*	P*	T*	P*/T*	W*T**.44	WP	WS	UP	UM	UU	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0	0.3302	0.9242	0.3573	0.0	1.928	0.0	116.01	38.73	40.05	0.034
2	0.1800	0.2342	0.9242	0.2534	0.1738	1.928	0.347	115.93	45.13	40.06	0.034
3	0.2855	0.1517	0.9242	0.1642	0.2757	1.928	0.550	115.86	49.02	40.04	0.034
4	0.4365	0.0861	0.9234	0.0933	0.4215	1.928	0.841	115.91	54.28	40.05	0.034
5	0.5521	0.0345	0.9234	0.0373	0.5331	1.928	1.064	115.86	58.39	40.04	0.034
6	0.5856	0.0172	0.9234	0.0187	0.5654	1.928	1.129	115.85	59.59	40.03	0.034
7	0.6533	0.0121	0.9234	0.0131	0.6308	1.928	1.259	115.85	62.00	40.03	0.034
8	0.6815	0.0086	0.9234	0.0093	0.6581	1.928	1.314	115.84	63.01	40.03	0.034
9	********	0.0	0.9234	0.0	********	1.928	*******	115.84	******	40.03	0.033

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION A

X/D:	0.0	0.5	1.0	1.5
-PMS(IN. H2O):	0.700	0.380	0.220	0.120
-PMS*:	0.241	0.131	0.076	0.041

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION B

X/D:	0.0	0.5	1.0	1.5
-PMS(IN. H2O):	0.560	0.350	0.250	0.120
-PMS*:	0.193	0.121	0.086	0.041

(b) S/D= 0.0; UPT Mach No.= 0.034

TABLE VIII. Continued.

DATA TAKEN ON 19 JULY 1977 BY MIKE MOSS
4 NOZZLE; S/D= 0.25; L/D= 2.0

NUMBER OF PRIMARY NOZZLES: 4
PRIMARY NOZZLE DIAMETER: 3.38 INCHES
MIXING STACK LENGTH: 23.40 INCHES
MIXING STACK DIAMETER: 11.70 INCHES
MIXING STACK L/D: 2.00

UPTAKE DIAMETER: 11.50 INCHES
AREA RATIO, AM/AP: 3.00
ORIFICE DIAMETER: 6.902 INCHES
ORIFICE BETA: 0.497
AMBIENT PRESSURE: 29.93 INCHES HG

N	PCR	DPCR	TOR	TUPT	TAMB	PU-PA	PA-PS	PA-PNZ	SECONDARY AREA
RUN	INCHES OF WATER		DEGREES FAHRENHEIT			INCHES OF WATER			SQUARE INCHES
1	0.7	22.0	68.0	121.0	80.0	5.00	4.22	4.24	0.0
2	0.7	22.0	68.0	121.0	80.0	6.00	3.06	3.06	12.566
3	0.7	21.8	68.0	121.0	80.0	6.70	2.20	2.20	25.133
4	0.7	21.8	68.0	121.0	80.0	7.50	1.06	1.06	50.265
5	0.7	22.0	68.0	121.0	80.0	8.40	0.50	0.50	100.531
6	0.7	22.0	68.0	121.0	80.0	8.60	0.28	0.28	150.796
7	0.7	22.2	68.5	122.0	80.0	8.70	0.17	0.17	201.062
8	0.7	22.0	68.5	121.0	80.0	8.80	0.11	0.11	248.186
9	0.7	22.0	68.5	121.0	80.0	8.80	0.0	0.0	**********

N	W*	P*	T*	P*/T*	W*T**.44	WP	WS	UP	UM	UU	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0	0.3572	0.9294	0.4274	0.0	3.707	0.0	219.90	73.41	75.59	0.064
2	0.2002	0.2897	0.9294	0.3117	0.1939	3.707	0.742	219.27	86.72	75.77	0.064
3	0.3411	0.2111	0.9294	0.2271	0.3303	3.650	1.259	217.81	95.64	75.26	0.064
4	0.4735	0.1023	0.9294	0.1100	0.4585	3.650	1.747	217.20	104.33	75.05	0.064
5	0.6474	0.0479	0.9294	0.0516	0.6269	3.707	2.400	217.89	116.45	75.29	0.064
6	0.7267	0.0269	0.9294	0.0289	0.7037	3.707	2.694	217.77	121.77	75.25	0.064
7	0.7520	0.0161	0.9278	0.0174	0.7276	3.722	2.799	218.97	124.08	75.66	0.064
8	0.7328	0.0101	0.9294	0.0109	0.7096	3.705	2.715	217.58	122.09	75.18	0.064
9	********	0.0	0.9294	0.0	********	3.705	*******	217.52	******	75.16	0.064

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION A

X/D:	0.0	0.5	1.0	1.5
-PMS(IN. H2O):	3.350	1.450	0.850	0.350
-PMS*:	0.322	0.139	0.082	0.034

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION B

X/D:	0.0	0.5	1.0	1.5
-PMS(IN. H2O):	2.340	1.350	0.840	0.400
-PMS*:	0.225	0.130	0.081	0.038

(c) S/D= 0.25; UPT Mach No.= 0.064

TABLE VIII. Continued.

DATA TAKEN ON 19 JULY 1977 BY MIKE MOSS
4 NOZZLE; S/D= 0.25; L/D= 2.0

NUMBER OF PRIMARY NOZZLES: 4	UPTAKE DIAMETER: 11.50 INCHES
PRIMARY NOZZLE DIAMETER: 3.38 INCHES	AREA RATIO, AM/AP: 3.00
MIXING STACK LENGTH: 23.40 INCHES	ORIFICE DIAMETER: 6.902 INCHES
MIXING STACK DIAMETER: 11.70 INCHES	ORIFICE BETA: 0.497
MIXING STACK L/D: 2.00	AMBIENT PRESSURE: 29.93 INCHES HG

N	POR	DPOR	TOR	TUPT	TAMB	PU-PA	PA-PS	PA-PNZ	SECONDARY AREA
RUN	INCHES OF WATER		DEGREES FAHRENHEIT			INCHES OF WATER			SQUARE INCHES
1	0.2	6.0	70.0	130.0	84.0	1.35	1.10	1.10	0.0
2	0.2	6.0	70.0	130.0	84.0	1.60	0.75	0.75	12.566
3	0.2	6.0	70.0	130.0	84.0	1.80	0.59	0.59	25.133
4	0.2	6.0	70.0	130.0	84.0	2.00	0.35	0.35	50.265
5	0.2	6.0	70.0	130.0	84.0	2.20	0.13	0.13	100.531
6	0.2	6.0	70.0	130.0	84.0	2.30	0.08	0.08	150.796
7	0.2	6.0	70.0	130.0	84.0	2.30	0.05	0.05	201.062
8	0.2	6.0	70.0	130.0	84.0	2.30	0.03	0.03	248.186
9	0.2	6.0	70.0	130.0	84.0	2.35	0.0	0.0	**********

N	W*	P*	T*	P*/T*	W*T**.44	WP	WS	UP	UM	LL	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0	0.3776	0.9220	0.4095	0.0	1.934	0.0	115.58	38.58	39.54	0.034
2	0.1893	0.2579	0.9220	0.2797	0.1827	1.934	0.366	115.48	45.27	39.50	0.034
3	0.3359	0.2030	0.9220	0.2202	0.3241	1.934	0.649	115.43	50.45	39.85	0.034
4	0.5174	0.1206	0.9220	0.1308	0.4992	1.934	1.000	115.36	56.87	39.86	0.033
5	0.6306	0.0448	0.9220	0.0486	0.6085	1.934	1.219	115.30	60.86	39.84	0.033
6	0.7421	0.0276	0.9220	0.0299	0.7160	1.934	1.435	115.29	64.81	39.84	0.033
7	0.7822	0.0173	0.9220	0.0187	0.7547	1.934	1.512	115.28	66.23	39.83	0.033
8	0.8078	0.0121	0.9220	0.0131	0.7795	1.934	1.562	115.27	67.14	39.83	0.033
9	********	0.0	0.9220	0.0	********	1.934	*******	115.26	******	39.83	0.033

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION A

X/D:	0.0	0.5	1.0	1.5
-PMS(IN. H2O):	0.760	0.420	0.240	0.110
-PMS*:	0.262	0.145	0.083	0.038

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION B

X/D:	0.0	0.5	1.0	1.5
-PMS(IN. H2O):	0.620	0.360	0.240	0.120
-PMS*:	0.214	0.124	0.083	0.041

(d) S/D= 0.25; UPT Mach No.= 0.034

TABLE VIII. Continued.

DATA TAKEN ON 19 JULY 1977 BY MIKE MOSS
4 NOZZLE; S/D= 0.5; L/D= 2.0

NUMBER OF PRIMARY NOZZLES: 4
PRIMARY NOZZLE DIAMETER: 3.38 INCHES
MIXING STACK LENGTH: 23.40 INCHES
MIXING STACK DIAMETER: 11.70 INCHES
MIXING STACK L/D: 2.00

UPTAKE DIAMETER: 11.50 INCHES
AREA RATIO, AM/AP: 3.00
ORIFICE DIAMETER: 6.502 INCHES
ORIFICE BETA: 0.497
AMBIENT PRESSURE: 29.93 INCHES HG

N RUN	POR	DPOR	TOR	TUPT	TAMB	PU-PA	PA-PS	PA-PNZ	SECONDARY AREA
	INCHES OF WATER		DEGREES FAHRENHEIT			INCHES OF WATER			SQUARE INCHES
1	0.7	22.0	54.0	106.0	65.0	4.90	4.22	4.22	0.0
2	0.7	22.0	54.0	106.0	65.0	5.55	3.06	3.06	12.566
3	0.7	22.0	54.0	106.0	65.0	6.70	2.22	2.22	25.133
4	0.7	22.0	54.0	106.0	65.0	7.60	1.26	1.26	50.265
5	0.7	22.0	54.0	107.0	65.0	8.50	0.52	0.52	100.531
6	0.7	22.0	54.0	107.5	65.0	8.60	0.28	0.28	150.796
7	0.7	22.0	54.0	108.0	65.0	8.70	0.17	0.17	201.062
8	0.7	22.0	54.0	108.0	65.0	8.80	0.11	0.11	248.186
9	0.7	22.0	54.0	108.0	65.0	9.00	0.01	0.01	**********

N RUN	W*	P*	T*	P*/T*	W*T**.44	WP	WS	UP	UM	UU	UPT MACH
						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0	0.3961	0.9275	0.4271	0.0	3.757	0.0	217.13	72.48	75.03	0.064
2	0.2003	0.2889	0.9275	0.3115	0.1938	3.757	0.753	216.50	85.60	74.81	0.064
3	0.3413	0.2105	0.9275	0.2269	0.3302	3.757	1.282	216.05	94.83	74.65	0.064
4	0.5142	0.1200	0.9275	0.1294	0.4975	3.757	1.932	215.54	106.17	74.48	0.064
5	0.6607	0.0495	0.9259	0.0535	0.6387	3.757	2.482	215.53	115.91	74.47	0.064
6	0.7272	0.0267	0.9251	0.0288	0.7027	3.757	2.732	215.59	120.35	74.50	0.064
7	0.7555	0.0162	0.9243	0.0175	0.7298	3.757	2.839	215.72	122.28	74.54	0.064
8	0.7502	0.0105	0.9243	0.0113	0.7246	3.757	2.819	215.69	121.91	74.53	0.064
9	********	0.0010	0.9243	0.0010	********	3.757	*******	215.64	******	74.51	0.064

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION A

X/D:	0.0	0.5	1.0	1.5
-PMS(IN. H2O):	3.450	1.300	0.720	0.270
-PMS*:	0.328	0.124	0.069	0.026

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION B

X/D:	0.0	0.5	1.0	1.5
-PMS(IN. H2O):	2.250	1.170	0.750	0.320
-PMS*:	0.214	0.111	0.071	0.030

(e) S/D= 0.50; UPT Mach No.= 0.064

TABLE VIII. Continued.

DATA TAKEN ON 19 JULY 1977 BY MIKE MOSS
4 NOZZLE; S/D= 0.5; L/D= 2.0

NUMBER OF PRIMARY NOZZLES: 4
PRIMARY NOZZLE DIAMETER: 3.38 INCHES
MIXING STACK LENGTH: 23.40 INCHES
MIXING STACK DIAMETER: 11.70 INCHES
MIXING STACK L/D: 2.00

UPTAKE DIAMETER: 11.50 INCHES
AREA RATIO, AM/AP: 3.00
ORIFICE DIAMETER: 6.902 INCHES
ORIFICE BETA: 0.497
AMBIENT PRESSURE: 29.53 INCHES HG

N RUN	PCR	PPCR	TCR	TUPT	TAMB	PU-PA	PA-PS	PA-PNZ	SECONDARY AREA
	INCHES OF WATER		DEGREES FAHRENHEIT			INCHES OF WATER			SQUARE INCHES
1	0.2	6.0	57.0	117.0	69.0	1.30	1.09	1.09	0.0
2	0.2	6.0	57.0	117.0	69.0	1.60	0.80	0.80	12.566
3	0.2	6.0	57.0	117.0	69.0	1.80	0.60	0.60	25.133
4	0.2	6.0	57.0	117.0	69.0	2.00	0.35	0.35	50.265
5	0.2	6.0	57.0	117.0	69.0	2.25	0.15	0.15	100.531
6	0.2	6.0	57.0	117.0	69.0	2.30	0.09	0.09	150.796
7	0.2	6.0	57.0	117.0	69.0	2.35	0.07	0.07	201.062
8	0.2	6.0	57.0	117.0	69.0	2.40	0.03	0.03	248.186
9	0.2	6.0	57.0	118.0	69.0	2.40	0.00	0.00	**********

N RUN	W*	P*	T*	P*/T*	W*T**.44	WP LBM/SEC	WS LBM/SEC	UP FT/SEC	UM FT/SEC	UL FT/SEC	UPT MACH
1	0.0	0.3711	0.9168	0.4048	0.0	1.958	0.0	114.44	38.20	39.54	0.034
2	0.1559	0.2728	0.9168	0.2975	0.1885	1.958	0.383	114.36	45.02	39.51	0.034
3	0.3392	0.2048	0.9168	0.2234	0.3265	1.958	0.664	114.30	50.01	39.50	0.034
4	0.5182	0.1196	0.9168	0.1305	0.4987	1.958	1.014	114.23	56.23	39.47	0.034
5	0.6671	0.0456	0.9168	0.0541	0.6420	1.958	1.306	114.17	61.41	39.45	0.034
6	0.7661	0.0291	0.9168	0.0317	0.7373	1.958	1.500	114.16	64.87	39.45	0.034
7	0.8532	0.0222	0.9168	0.0243	0.8597	1.958	1.749	114.15	69.31	39.44	0.034
8	0.8091	0.0120	0.9168	0.0131	0.7787	1.958	1.584	114.14	66.36	39.44	0.034
9	********	0.0017	0.9152	0.0019	********	1.958	*******	114.33	******	39.51	0.034

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION A

X/D:	0.0	0.5	1.0	1.5
-PMS(IN. H2O):	0.820	0.370	0.200	0.090
-PMS*:	0.280	0.126	0.068	0.031

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION B

X/D:	0.0	0.5	1.0	1.5
-PMS(IN. H2O):	0.620	0.330	0.200	0.100
-PMS*:	0.211	0.113	0.068	0.034

(f) S/D= 0.50; UPT Mach No.= 0.034

TABLE VIII. Continued.

DATA TAKEN ON 22 JULY 1977 BY MIKE MOSS
4 NOZZLE; S/D=.75; L/D=2.0

NUMBER OF PRIMARY NOZZLES: 4
PRIMARY NOZZLE DIAMETER: 3.38 INCHES
MIXING STACK LENGTH: 23.40 INCHES
MIXING STACK DIAMETER: 11.70 INCHES
MIXING STACK L/D: 2.00

UPTAKE DIAMETER: 11.50 INCHES
AREA RATIO, AM/AP: 3.00
ORIFICE DIAMETER: 6.932 INCHES
ORIFICE BETA: 0.497
AMBIENT PRESSURE: 30.01 INCHES HG

N	FOP	DPOR	TOR	TUPT	TAMB	PU-PA	PA-PS	PA-PN2	SECONDARY AREA
RUN	INCHES OF WATER		DEGREES FAHRENHEIT			INCHES OF WATER			SQUARE INCHES
1	0.7	22.0	65.0	117.0	82.0	4.80	4.30	4.30	0.0
2	0.7	22.0	65.0	117.0	82.0	6.00	3.10	3.10	12.566
3	0.7	22.0	65.0	117.0	82.0	6.70	2.23	2.23	25.133
4	0.7	22.0	65.0	117.0	82.0	7.70	1.25	1.25	50.265
5	0.7	22.0	65.0	117.0	82.0	8.50	0.49	0.49	100.531
6	0.7	22.0	65.0	117.0	82.0	8.70	0.27	0.27	150.796
7	0.7	22.0	65.0	117.0	82.0	8.80	0.16	0.16	201.062
8	0.7	22.0	65.0	117.0	82.0	8.80	0.10	0.10	248.186
9	0.7	22.0	65.0	117.0	82.0	9.00	0.0	0.0	***********

N	W*	P*	T*	P*/T*	W*T**.44	WP	WS	UP	US	UC	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0	0.4094	0.9393	0.4359	0.0	3.723	0.0	218.76	73.03	75.59	0.064
2	0.2006	0.2569	0.9393	0.2161	0.1551	3.723	0.747	218.11	86.42	75.37	0.064
3	0.3402	0.2145	0.9393	0.2284	0.3310	3.723	1.267	217.64	95.75	75.20	0.064
4	0.5094	0.1208	0.9393	0.1286	0.4556	3.723	1.896	217.12	107.06	75.02	0.064
5	0.6379	0.0475	0.9393	0.0506	0.6206	3.723	2.375	216.71	115.64	74.88	0.064
6	0.7103	0.0262	0.9393	0.0279	0.6910	3.723	2.644	216.60	120.52	74.84	0.064
7	0.7291	0.0155	0.9393	0.0166	0.7092	3.723	2.714	216.54	121.77	74.82	0.064
8	0.7115	0.0097	0.9393	0.0103	0.6921	3.723	2.649	216.51	120.56	74.81	0.064
9	********	0.0	0.9393	0.0	********	3.723	*******	216.45	******	74.79	0.064

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION A

X/D:	0.0	0.5	1.0	1.5
-PMS(IN. H2O):	2.800	0.520	0.450	0.150
-PMS*:	0.272	0.089	0.044	0.015

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION B

X/D:	0.0	0.5	1.0	1.5
-PMS(IN. H2O):	1.900	0.880	0.520	0.200
-PMS*:	0.185	0.086	0.051	0.019

(g) S/D= 0.75; UPT Mach No.= 0.064

TABLE VIII. Continued.

DATA TAKEN ON 22 JULY 1977 BY MIKE MOSS
4 NOZZLE; S/D=.75; L/D=2.0

NUMBER OF PRIMARY NOZZLES: 4
PRIMARY NOZZLE DIAMETER: 3.38 INCHES
MIXING STACK LENGTH: 23.40 INCHES
MIXING STACK DIAMETER: 11.70 INCHES
MIXING STACK L/D: 2.00

UPTAKE DIAMETER: 11.50 INCHES
AREA RATIO, AM/AP: 3.00
ORIFICE DIAMETER: 6.902 INCHES
ORIFICE BETA: 0.497
AMBIENT PRESSURE: 30.01 INCHES HG

N	PCR	DPCR	TCR	TUPT	TAMB	PU-PA	PA-PS	PA-PNZ	SECONDARY AREA
RUN	INCHES OF WATER		DEGREES FAHRENHEIT			INCHES OF WATER			SQUARE INCHES
1	0.2	6.0	66.0	128.0	82.0	1.30	1.13	1.13	0.0
2	0.2	6.0	66.0	128.0	82.0	1.60	0.83	0.83	12.566
3	0.2	6.0	66.0	128.0	82.0	1.80	0.60	0.60	25.133
4	0.2	6.0	66.0	128.0	82.0	2.10	0.35	0.36	50.265
5	0.2	6.0	66.0	128.0	82.0	2.25	0.15	0.15	100.531
6	0.2	6.0	66.0	128.0	82.0	2.30	0.08	0.08	150.796
7	0.2	6.0	66.0	128.0	82.0	2.35	0.04	0.04	201.062
8	0.2	6.0	66.0	128.0	82.0	2.40	0.03	0.03	248.186
9	0.2	6.0	66.0	128.0	82.0	2.40	0.0	0.0	**********

N	W*	P*	T*	P*/T*	W*T**.44	WP	WS	UP	UP	UU	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0	0.3861	0.9217	0.4189	0.0	1.943	0.0	115.48	38.55	39.90	0.034
2	0.1982	0.2623	0.9217	0.3063	0.1912	1.943	0.385	115.39	45.54	39.87	0.034
3	0.2380	0.2055	0.9217	0.2230	0.3261	1.943	0.657	115.33	50.48	39.85	0.034
4	0.5237	0.1200	0.9217	0.1302	0.5052	1.943	1.018	115.25	57.03	39.83	0.034
5	0.6761	0.0515	0.9217	0.0559	0.6523	1.943	1.314	115.20	62.41	39.81	0.033
6	0.7171	0.0258	0.9217	0.0279	0.6918	1.943	1.394	115.18	63.86	39.80	0.033
7	0.7406	0.0155	0.9217	0.0168	0.7145	1.943	1.439	115.17	64.69	39.80	0.033
8	0.8062	0.0120	0.9217	0.0130	0.7770	1.943	1.567	115.17	67.01	39.79	0.033
9	********	0.0	0.9217	0.0	********	1.943	*******	115.16	******	39.79	0.033

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION A

X/D:	0.0	0.5	1.0	1.5
-PMS(IN. H2O):	0.710	0.270	0.140	0.045
-PMS*:	0.244	0.093	0.040	0.015

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION B

X/D:	0.0	0.5	1.0	1.5
-PMS(IN. H2O):	0.530	0.280	0.170	0.060
-PMS*:	0.182	0.096	0.058	0.021

(h) S/D= 0.75; UPT Mach No.= 0.034

TABLE VIII. Continued.

DATA TAKEN ON 18 JULY 1977 BY MIKE MOSS
4 NOZZLE; S/D= 1.0; L/D= 2.0

NUMBER OF PRIMARY NOZZLES: 4
PRIMARY NOZZLE DIAMETER: 3.38 INCHES
MIXING STACK LENGTH: 23.40 INCHES
MIXING STACK DIAMETER: 11.70 INCHES
MIXING STACK L/D: 2.00

UPTAKE DIAMETER: 11.50 INCHES
AREA RATIO, AM/AP: 3.00
ORIFICE DIAMETER: 6.902 INCHES
ORIFICE BETA: 0.497
AMBIENT PRESSURE: 29.90 INCHES HG

N	PCR	DPOR	TOR	TUPT	TAMB	PU-PA	PA-PS	PA-PNZ	SECONDARY AREA
RUN	INCHES OF WATER		DEGREES FAHRENHEIT			INCHES OF WATER			SQUARE INCHES
1	0.7	22.0	57.0	110.0	69.0	4.80	4.18	4.18	0.0
2	0.7	22.0	57.0	110.0	69.0	5.85	3.08	3.08	12.566
3	0.7	22.0	57.0	110.0	69.0	6.80	2.20	2.20	25.133
4	0.7	22.0	58.0	111.0	69.0	7.70	1.22	1.24	50.265
5	0.7	22.0	58.0	111.0	69.0	8.50	0.48	0.48	100.531
6	0.7	22.0	58.0	111.0	69.0	8.70	0.29	0.29	150.796
7	0.7	22.0	58.0	111.0	69.0	8.85	0.17	0.17	201.062
8	0.7	22.0	58.0	111.0	69.0	8.90	0.12	0.12	248.186
9	0.7	22.0	58.0	111.0	69.0	9.10	0.01	0.01	**********

N	W*	P*	T*	P*/T*	W*T**.44	WP	WS	UP	UM	UU	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0	0.3522	0.5280	0.4226	0.0	3.745	0.0	218.11	72.81	75.37	0.064
2	0.2008	0.2905	0.5280	0.3131	0.1543	3.745	0.752	217.52	86.04	75.16	0.064
3	0.3394	0.2084	0.5280	0.2246	0.3285	3.745	1.271	217.05	95.16	75.00	0.064
4	0.5102	0.1160	0.5264	0.1252	0.4533	3.741	1.908	216.69	106.42	74.88	0.064
5	0.6348	0.0458	0.5264	0.0494	0.6138	3.741	2.375	216.30	114.62	74.74	0.064
6	0.7401	0.0277	0.5264	0.0299	0.7157	3.741	2.769	216.20	121.62	74.70	0.064
7	0.7556	0.0162	0.5264	0.0175	0.7306	3.741	2.827	216.13	122.63	74.68	0.064
8	0.7836	0.0115	0.5264	0.0124	0.7577	3.741	2.931	216.11	124.50	74.67	0.064
9	********	0.0010	0.5264	0.0010	********	3.741	*******	216.05	******	74.65	0.064

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION A

X/D:	0.0	0.5	1.0	1.5
-PMS(IN. H2O):	2.500	0.780	0.350	0.100
-PMS*:	0.239	0.075	0.033	0.010

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION B

X/D:	0.0	0.5	1.0	1.5
-PMS(IN. H2O):	1.750	0.780	0.430	0.120
-PMS*:	0.167	0.075	0.041	0.011

(i) S/D= 1.0; UPT Mach No.= 0.064

TABLE VIII. Continued.

DATA TAKEN ON 10 JULY 1977 BY MIKE MOSS
4 NOZZLE; S/D= 1.0; L/D= 2.0

NUMBER OF PRIMARY NOZZLES: 4
PRIMARY NOZZLE DIAMETER: 3.38 INCHES
MIXING STACK LENGTH: 23.40 INCHES
MIXING STACK DIAMETER: 11.70 INCHES
MIXING STACK L/D: 2.00

UPTAKE DIAMETER: 11.50 INCHES
AREA RATIO, AM/AP: 3.00
ORIFICE DIAMETER: 6.902 INCHES
ORIFICE BETA: 0.497
AMBIENT PRESSURE: 29.90 INCHES HG

N	PCR	CPCR	TCR	TUPT	TAMB	PU-PA	PA-PS	PA-PNZ	SECONDARY AREA
RUN	INCHES OF WATER		DEGREES FAHRENHEIT			INCHES OF WATER			SQUARE INCHES
1	0.2	6.0	58.0	119.0	69.0	1.30	1.02	1.02	0.0
2	0.2	6.0	58.0	119.0	69.0	1.60	0.80	0.80	12.566
3	0.2	6.0	58.0	119.0	69.0	1.85	0.60	0.60	25.133
4	0.2	6.0	58.0	119.0	69.0	2.10	0.35	0.35	50.265
5	0.2	6.0	58.0	119.0	69.0	2.30	0.15	0.15	100.531
6	0.2	6.0	58.0	119.0	69.0	2.35	0.08	0.08	150.796
7	0.2	6.0	58.0	119.0	69.0	2.40	0.05	0.05	201.062
8	0.2	6.0	58.0	119.0	69.0	2.40	0.04	0.04	248.186
9	0.2	6.0	58.0	119.0	69.0	2.40	0.01	0.01	**********

N	W*	P*	T*	P*/T*	W*T**.44	WP	WS	UP	UM	UL	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0	0.3457	0.9136	0.3783	0.0	1.955	0.0	114.76	38.31	39.66	0.034
2	0.1960	0.2714	0.9136	0.2971	0.1884	1.955	0.383	114.70	45.14	39.63	0.034
3	0.3396	0.2037	0.9136	0.2230	0.3263	1.955	0.664	114.65	50.13	39.61	0.034
4	0.5167	0.1190	0.9136	0.1303	0.4985	1.955	1.014	114.57	56.36	39.59	0.034
5	0.6791	0.0510	0.9136	0.0559	0.6526	1.955	1.328	114.52	61.94	39.57	0.034
6	0.7439	0.0272	0.9136	0.0298	0.7149	1.955	1.454	114.50	64.20	39.56	0.034
7	0.7842	0.0170	0.9136	0.0186	0.7536	1.955	1.533	114.49	65.60	39.56	0.034
8	0.8658	0.0136	0.9136	0.0149	0.8320	1.955	1.692	114.49	68.45	39.56	0.034
9	********	0.0034	0.9136	0.0037	********	1.955	*******	114.48	******	39.56	0.034

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION A

X/D:	0.0	0.5	1.0	1.5
-PMS(IN. H2O):	0.660	0.220	0.100	0.035
-PMS*:	0.225	0.075	0.034	0.012

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION B

X/D:	0.0	0.5	1.0	1.5
-PMS(IN. H2O):	0.470	0.150	0.125	0.040
-PMS*:	0.160	0.051	0.043	0.014

(j) S/D= 1.0; UPT Mach No.= 0.034

TABLE VIII. Continued.

DATA TAKEN ON 5 AUGUST 1977 BY MIKE MOSS

4 NOZZLE: S/D= -.25; L/D= 2.0; WITH TRANSITION

NUMBER OF PRIMARY NOZZLES: 4
PRIMARY NOZZLE DIAMETER: 3.38 INCHES
MIXING STACK LENGTH: 23.40 INCHES
MIXING STACK DIAMETER: 11.70 INCHES
MIXING STACK L/D: 2.00

UPTAKE DIAMETER: 11.50 INCHES
AREA RATIO, AM/AP: 3.00
ORIFICE DIAMETER: 6.902 INCHES
ORIFICE BETA: 0.497
AMBIENT PRESSURE: 29.89 INCHES HG

N	PCR	DPCR	TCR	TUPT	TAMB	PU-PA	PA-PS	PA-PNZ	SECONDARY AREA
RUN	INCHES OF WATER		DEGREES FAHRENHEIT			INCHES OF WATER			SQUARE INCHES
1	0.7	22.0	57.0	109.4	68.0	5.00	3.86	3.86	0.0
2	0.7	22.0	57.0	109.4	68.0	6.10	2.66	2.66	12.566
3	0.7	22.0	57.0	109.4	68.0	6.80	1.95	1.55	25.133
4	0.7	22.0	57.0	109.4	68.0	7.70	0.58	1.01	50.265
5	0.7	22.0	57.0	109.4	68.0	0.25	0.37	0.37	100.531
6	0.7	22.0	57.0	110.0	68.0	8.35	0.15	0.19	150.796
7	0.7	22.0	57.0	110.5	68.0	8.45	0.10	0.10	201.062
8	0.7	22.0	57.0	110.5	68.0	8.50	0.08	0.08	248.186
9	0.7	22.0	57.0	110.5	68.0	8.50	0.01	0.01	**********

N	W*	F*	T*	P*/T*	W*T**.44	WP	WS	UP	UM	LL	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0	0.3628	0.5272	0.3912	0.0	3.744	0.0	217.75	72.65	75.24	0.064
2	0.1868	0.2515	0.5272	0.2712	0.1807	3.744	0.659	217.10	84.55	75.02	0.064
3	0.3199	0.1850	0.5272	0.1995	0.3054	3.744	1.158	216.72	93.70	74.89	0.064
4	0.4604	0.0934	0.5272	0.1008	0.4454	3.744	1.724	216.20	102.91	74.71	0.064
5	0.5573	0.0354	0.5272	0.0382	0.5351	3.744	2.087	215.88	109.27	74.59	0.064
6	0.5951	0.0181	0.5263	0.0196	0.5792	3.744	2.243	216.01	112.11	74.64	0.064
7	0.5795	0.0095	0.5255	0.0133	0.5601	3.744	2.170	216.15	110.84	74.69	0.064
8	0.6195	0.0072	0.5255	0.0077	0.5987	3.744	2.319	216.14	113.51	74.68	0.064
9	********	0.0010	0.5255	0.0010	********	3.744	*******	216.10	******	74.67	0.064

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION A

X/D:	-1.0	-0.5	0.0	0.5
-PMS(IN. H2O):	0.520	0.330	0.660	0.340
-PMS*:	0.050	0.031	0.063	0.032

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION B

X/D:	-1.0	-0.5	0.0	0.5
-PMS(IN. H2O):	0.470	0.330	0.550	0.340
-PMS*:	0.045	0.031	0.052	0.032

(a) S/D= -0.25; UPT Mach No.= 0.064

TABLE IX. Tabulated Performance Data for L/D= 2 with an Entrance Transition

DATA TAKEN ON 5 AUGUST 1977 BY MIKE MOSS
4 NOZZLE; S/D= -.25; L/D= 2.0; WITH TRANSITION

NUMBER OF PRIMARY NOZZLES: 4	UPTAKE DIAMETER: 11.50 INCHES
PRIMARY NOZZLE DIAMETER: 3.38 INCHES	AREA RATIO, AM/AP: 3.00
MIXING STACK LENGTH: 23.40 INCHES	ORIFICE DIAMETER: 6.902 INCHES
MIXING STACK DIAMETER: 11.70 INCHES	ORIFICE BETA: 0.497
MIXING STACK L/D: 2.00	AMBIENT PRESSURE: 29.89 INCHES HG

N	PCR	DPCR	TCR	TUPT	TAMB	PU-PA	PA-PS	PA-PNZ	SECONDARY AREA
RUN	INCHES OF WATER		DEGREES FAHRENHEIT			INCHES OF WATER			SQUARE INCHES
1	0.2	6.0	58.5	120.0	71.0	1.40	1.00	1.01	0.0
2	0.2	6.0	58.5	120.0	71.0	1.70	0.72	0.72	12.566
3	0.2	6.0	58.0	120.0	71.0	1.90	0.51	0.51	25.133
4	0.2	6.0	58.0	120.0	71.0	2.10	0.27	0.27	50.265
5	0.2	6.0	58.0	120.0	71.0	2.30	0.10	0.10	100.531
6	0.2	6.0	58.0	120.0	71.0	2.30	0.05	0.05	150.796
7	0.2	6.0	58.0	120.0	71.0	2.30	0.03	0.03	201.062
8	0.2	6.0	58.0	120.0	71.0	2.35	0.03	0.03	248.186
9	0.2	6.0	58.0	120.0	71.0	2.35	0.0	0.0	**********

N	W*	P*	T*	P*/T*	W*T**.44	WP	WS	UP	UM	UU	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0	0.3394	0.9155	0.3707	0.0	1.954	0.0	114.92	38.36	35.71	0.034
2	0.1857	0.2447	0.9155	0.2673	0.1786	1.954	0.363	114.84	44.84	35.68	0.034
3	0.3125	0.1733	0.9155	0.1893	0.3006	1.954	0.611	114.84	49.29	35.68	0.034
4	0.4547	0.0919	0.9155	0.1003	0.4374	1.954	0.889	114.77	54.25	35.66	0.034
5	0.5535	0.0341	0.9155	0.0372	0.5324	1.954	1.082	114.72	57.70	35.64	0.034
6	0.5870	0.0170	0.9155	0.0186	0.5646	1.954	1.147	114.71	58.87	35.64	0.034
7	0.6549	0.0119	0.9155	0.0130	0.6299	1.954	1.280	114.70	61.24	35.63	0.034
8	0.6832	0.0085	0.9155	0.0093	0.6571	1.954	1.335	114.70	62.24	35.63	0.034
9	********	0.0	0.9155	0.0	********	1.954	*******	114.69	******	35.63	0.034

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION A

X/D:	-1.0	-0.5	0.0	0.5
-PMS(IN. H2O):	0.140	0.100	0.200	0.110
-PMS*:	0.048	0.034	0.068	0.037

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION B

X/D:	-1.0	-0.5	0.0	0.5
-PMS(IN. H2O):	0.140	0.100	0.170	0.110
-PMS*:	0.048	0.034	0.058	0.037

(b) S/D= -0.25; UPT Mach no.= 0.034

TABLE IX. Continued.

DATA TAKEN ON 4 AUGUST 1977 BY MIKE MOSS

4 NOZZLE; S/D= 0.0; L/D= 2.0; WITH TRANSITION

NUMBER OF PRIMARY NOZZLES: 4	UPTAKE DIAMETER: 11.50 INCHES
PRIMARY NOZZLE DIAMETER: 3.38 INCHES	AREA RATIO, AM/AP: 3.00
MIXING STACK LENGTH: 23.40 INCHES	ORIFICE DIAMETER: 6.902 INCHES
MIXING STACK DIAMETER: 11.70 INCHES	ORIFICE BETA: 0.497
MIXING STACK L/D: 2.00	AMBIENT PRESSURE: 29.91 INCHES HG

N	POR	DPOR	TPR	TUPT	TAMB	PU-PA	PA-PS	PA-PNZ	SECONDARY AREA
RUN	INCHES OF WATER		DEGREES FAHRENHEIT			INCHES OF WATER			SQUARE INCHES
1	0.7	22.0	63.0	117.0	80.0	5.10	3.78	3.78	0.0
2	0.7	22.0	63.0	117.5	80.0	6.10	2.78	2.78	12.566
3	0.7	22.0	63.0	118.0	80.0	6.90	1.94	1.56	25.133
4	0.7	22.0	63.0	118.4	80.0	7.65	1.03	1.05	50.265
5	0.7	22.0	63.0	118.4	80.0	8.30	0.40	0.40	100.531
6	0.7	22.0	63.0	118.4	80.0	8.50	0.22	0.23	150.796
7	0.7	22.0	63.0	118.4	80.0	8.60	0.13	0.13	201.062
8	0.7	22.0	63.0	118.4	80.0	8.70	0.08	0.08	248.186
9	0.7	22.0	63.0	118.4	80.0	8.75	0.01	0.01	**********

N	W*	F*	T*	P*/T*	W*T**.44	WP	WS	UP	UM	UU	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0	0.3581	0.9358	0.3826	0.0	3.724	0.0	219.27	73.20	75.77	0.064
2	0.1899	0.2642	0.9350	0.2826	0.1844	3.724	0.707	218.92	85.57	75.64	0.064
3	0.3189	0.1848	0.9342	0.1978	0.3055	3.724	1.188	218.65	94.64	75.55	0.064
4	0.4669	0.0984	0.9336	0.1054	0.4530	3.724	1.738	218.31	104.56	75.44	0.064
5	0.5763	0.0383	0.9336	0.0411	0.5592	3.724	2.146	217.97	111.68	75.32	0.064
6	0.6555	0.0221	0.9336	0.0236	0.6360	3.724	2.441	217.88	117.22	75.29	0.064
7	0.6571	0.0125	0.9336	0.0134	0.6375	3.724	2.447	217.83	117.31	75.27	0.064
8	0.6363	0.0077	0.9336	0.0082	0.6173	3.724	2.369	217.80	115.89	75.26	0.064
9	********	0.0010	0.9336	0.0010	********	3.724	*******	217.77	******	75.25	0.064

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION A

X/D:	-1.0	-0.5	0.0	0.5
-PMS(IN. H2O):	0.410	0.290	0.560	0.320
-PMS*:	0.039	0.028	0.054	0.031

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION B

X/D:	-1.0	-0.5	0.0	0.5
-PMS(IN. H2O):	0.380	0.300	0.540	0.320
-PMS*:	0.036	0.029	0.052	0.031

(c) S/D= 0.0; UPT Mach No.= 0.064

TABLE IX. Continued.

DATA TAKEN ON 4 AUGUST 1977 BY MIKE MOSS
4 NOZZLE; S/D= 0.0; L/D= 2.0; WITH TRANSITION

NUMBER OF PRIMARY NOZZLES: 4
PRIMARY NOZZLE DIAMETER: 3.38 INCHES
MIXING STACK LENGTH: 23.40 INCHES
MIXING STACK DIAMETER: 11.70 INCHES
MIXING STACK L/D: 2.00

UPTAKE DIAMETER: 11.50 INCHES
AREA RATIO, AM/AP: 3.00
ORIFICE DIAMETER: 6.902 INCHES
ORIFICE BETA: 0.497
AMBIENT PRESSURE: 29.51 INCHES HG

N RUN	PCR	DPCP	TOR	TUPT	TAMB	PU-PA	PA-PS	PA-PNZ	SECONDARY AREA
	INCHES OF WATER		DEGREES FAHRENHEIT			INCHES OF WATER			SQUARE INCHES
1	0.2	6.0	66.0	129.2	84.0	1.40	1.00	1.00	0.0
2	0.2	6.0	68.0	129.2	84.0	1.65	0.74	0.74	12.566
3	0.2	6.0	68.0	129.5	84.0	1.85	0.53	0.53	25.133
4	0.2	6.0	68.0	129.5	84.0	2.10	0.30	0.30	50.265
5	0.2	6.0	68.0	129.5	84.0	2.30	0.11	0.11	100.531
6	0.2	6.0	69.0	129.5	84.0	2.30	0.06	0.06	150.796
7	0.2	6.0	68.0	129.5	84.0	2.30	0.04	0.04	201.062
8	0.2	6.0	68.0	129.5	84.0	2.35	0.03	0.03	248.186
9	0.2	6.0	68.0	129.5	84.0	2.40	0.00	0.00	**********

N RUN	W*	P*	T*	P*/T*	W*T**.44	WP LBM/SEC	WS LBM/SEC	UP FT/SEC	UM FT/SEC	UL FT/SEC	UPT MACH
1	0.0	0.3431	0.9232	0.3716	0.0	1.937	0.0	115.65	38.61	35.56	0.034
2	0.1877	0.2542	0.9232	0.2753	0.1812	1.937	0.364	115.57	45.26	35.54	0.034
3	0.3177	0.1821	0.9228	0.1973	0.3067	1.937	0.615	115.57	49.88	35.54	0.034
4	0.4781	0.1032	0.9228	0.1118	0.4615	1.937	0.926	115.51	55.56	35.51	0.034
5	0.5790	0.0379	0.9228	0.0410	0.5589	1.937	1.121	115.45	59.13	35.85	0.034
6	0.6414	0.0207	0.9228	0.0224	0.6191	1.937	1.242	115.44	61.34	35.85	0.034
7	0.6983	0.0138	0.9228	0.0149	0.6740	1.937	1.352	115.43	63.36	35.85	0.034
8	0.6814	0.0086	0.9228	0.0093	0.6578	1.937	1.320	115.43	62.76	35.85	0.034
9	********	0.0017	0.9228	0.0019	********	1.937	*******	115.42	******	35.88	0.034

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION A

X/D:	-1.0	-0.5	0.0	0.5
-PMS(IN. H2O):	0.110	0.090	0.180	0.100
-PMS*:	0.038	0.031	0.062	0.034

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION B

X/D:	-1.0	-0.5	0.0	0.5
-PMS(IN. H2O):	0.120	0.090	0.180	0.110
-PMS*:	0.041	0.031	0.062	0.038

(d) S/D= 0.0; UPT Mach No.= 0.034

TABLE IX. Continued.

DATA TAKEN ON 4 AUGUST 1977 BY MIKE MOSS
4 NOZZLE; S/D= .25; L/D= 2.0; WITH TRANSITION

NUMBER OF PRIMARY NOZZLES: 4
PRIMARY NOZZLE DIAMETER: 3.38 INCHES
MIXING STACK LENGTH: 23.40 INCHES
MIXING STACK DIAMETER: 11.70 INCHES
MIXING STACK L/D: 2.00

UPTAKE DIAMETER: 11.50 INCHES
AREA RATIO, AM/AP: 3.00
ORIFICE DIAMETER: 6.902 INCHES
ORIFICE BETA: 0.497
AMBIENT PRESSURE: 29.92 INCHES HG

N	FCR	DFCR	TOR	TUPT	TAMB	PU-PA	PA-PS	PA-PNZ	SECONDARY AREA
RUN	INCHES OF WATER		DEGREES FAHRENHEIT			INCHES OF WATER			SQUARE INCHES
1	0.7	22.0	58.0	112.0	74.0	5.40	3.64	3.64	0.0
2	0.7	22.0	58.0	112.0	74.0	6.10	2.86	2.86	12.566
3	0.7	22.0	58.0	112.0	74.0	6.80	2.04	2.04	25.133
4	0.7	22.0	58.0	112.0	74.0	7.80	1.14	1.17	50.265
5	0.7	22.0	58.0	112.0	74.0	8.40	0.44	0.45	100.531
6	0.7	22.0	58.0	112.0	74.0	8.60	0.25	0.25	150.796
7	0.7	22.0	58.0	112.0	74.0	8.70	0.15	0.15	201.062
8	0.7	22.0	58.0	112.0	74.0	8.70	0.10	0.10	248.186
9	0.7	22.0	58.0	111.5	74.0	8.80	0.00	0.00	**********

N	W*	F*	T*	P*/T*	W*T**.44	WP	WS	UF	UM	UO	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0	0.2439	0.9335	0.3684	0.0	3.742	0.0	218.30	72.87	75.43	0.064
2	0.1928	0.2713	0.9335	0.2906	0.1870	3.742	0.721	217.88	85.73	75.29	0.064
3	0.3256	0.1943	0.9335	0.2081	0.3159	3.742	1.219	217.44	94.54	75.13	0.064
4	0.4932	0.1090	0.9335	0.1168	0.4785	3.742	1.846	216.96	105.68	74.97	0.064
5	0.6118	0.0422	0.9335	0.0452	0.5935	3.742	2.289	216.58	113.55	74.84	0.064
6	0.6840	0.0240	0.9335	0.0257	0.6636	3.742	2.560	216.48	118.38	74.80	0.064
7	0.7064	0.0144	0.9335	0.0154	0.6854	3.742	2.643	216.43	119.88	74.78	0.064
8	0.7120	0.0096	0.9335	0.0103	0.6907	3.742	2.664	216.40	120.24	74.78	0.064
9	********	0.0005	0.9343	0.0005	********	3.742	*******	216.16	******	74.69	0.064

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION A

X/D:	-1.0	-0.5	0.0	0.5
-PMS(IN. H2O):	0.340	0.230	0.600	0.270
-PMS*:	0.033	0.022	0.058	0.026

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION B

X/D:	-1.0	-0.5	0.0	0.5
-PMS(IN. H2O):	0.270	0.190	0.500	0.270
-PMS*:	0.026	0.018	0.048	0.026

(e) S/D= 0.25; UPT Mach No.= 0.064

TABLE IX. Continued.

DATA TAKEN ON 4 AUGUST 1977 BY MIKE MOSS
4 NOZZLE; S/D= .25; L/D= 2.0; WITH TRANSITION

NUMBER OF PRIMARY NOZZLES: 4
PRIMARY NOZZLE DIAMETER: 3.38 INCHES
MIXING STACK LENGTH: 23.40 INCHES
MIXING STACK DIAMETER: 11.70 INCHES
MIXING STACK L/D: 2.00

UPTAKE DIAMETER: 11.50 INCHES
AREA RATIO, AM/AP: 3.00
ORIFICE DIAMETER: 6.902 INCHES
ORIFICE BETA: 0.497
AMBIENT PRESSURE: 29.92 INCHES HG

N	PCR	DPCR	TOR	TUPT	TAMB	PU-PA	PA-PS	PA-PNZ	SECONDARY AREA
RUN	INCHES OF WATER		DEGREES FAHRENHEIT			INCHES OF WATER			SQUARE INCHES
1	0.2	6.0	60.0	120.4	74.0	1.45	0.98	0.98	0.0
2	0.2	6.0	60.0	120.4	74.0	1.65	0.77	0.77	12.566
3	0.2	6.0	60.0	121.0	74.0	1.90	0.57	0.57	25.133
4	0.2	6.0	60.0	121.0	74.0	2.10	0.33	0.35	50.265
5	0.2	6.0	60.0	121.0	74.0	2.30	0.13	0.13	100.531
6	0.2	6.0	60.0	121.0	74.0	2.40	0.08	0.08	150.796
7	0.2	6.0	60.0	122.0	74.0	2.40	0.04	0.04	201.062
8	0.2	6.0	60.0	122.0	74.0	2.40	0.03	0.03	248.186
9	0.2	6.0	60.0	122.0	74.0	2.45	0.00	0.00	**********

N	W*	P*	T*	P*/T*	W*T**.44	WP	WS	UP	UM	UU	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0	0.3350	0.9200	0.3641	0.0	1.952	0.0	114.77	38.31	35.66	0.034
2	0.1918	0.2635	0.9203	0.2864	0.1849	1.952	0.374	114.71	45.04	35.64	0.034
3	0.3300	0.1548	0.9191	0.2120	0.3180	1.952	0.644	114.77	49.92	35.66	0.034
4	0.5172	0.1129	0.9191	0.1229	0.4984	1.952	1.010	114.70	56.48	35.63	0.034
5	0.6305	0.0445	0.9191	0.0485	0.6075	1.952	1.230	114.65	60.44	35.62	0.034
6	0.7183	0.0257	0.9191	0.0280	0.6921	1.952	1.402	114.63	63.53	35.61	0.034
7	0.6994	0.0137	0.9175	0.0149	0.6734	1.952	1.365	114.82	62.92	35.67	0.034
8	0.7477	0.0102	0.9175	0.0112	0.7199	1.952	1.459	114.82	64.62	35.67	0.034
9	********	0.0017	0.9175	0.0019	********	1.952	*******	114.81	******	35.67	0.034

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION A

X/D:	-1.0	-0.5	0.0	0.5
-PMS(IN. H2O):	0.100	0.070	0.180	0.090
-PMS*:	0.034	0.024	0.061	0.031

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION B

X/D:	-1.0	-0.5	0.0	0.5
-PMS(IN. H2O):	0.080	0.070	0.160	0.090
-PMS*:	0.027	0.024	0.055	0.031

(f) S/D= 0.25; UPT Mach No.= 0.034

TABLE IX. Continued.

DATA TAKEN ON 3 AUGUST 1977 BY MIKE MOSS
4 NOZZLE; S/D=.5; L/D= 2.0; WITH TRANSITION

NUMBER OF PRIMARY NOZZLES:	4	UPTAKE DIAMETER:	11.50 INCHES
PRIMARY NOZZLE DIAMETER:	3.38 INCHES	AREA RATIO, AM/AP:	3.00
MIXING STACK LENGTH:	23.40 INCHES	ORIFICE DIAMETER:	6.902 INCHES
MIXING STACK DIAMETER:	11.70 INCHES	ORIFICE BETA:	0.497
MIXING STACK L/D:	2.00	AMBIENT PRESSURE:	29.92 INCHES HG

N	PCR	DPCR	TOR	TUPT	TAMB	PU-PA	PA-PS	PA-PNZ	SECONDARY AREA
RUN	INCHES OF WATER		DEGREES FAHRENHEIT			INCHES OF WATER			SQUARE INCHES
1	0.7	22.0	55.0	109.0	66.0	5.50	3.38	3.38	0.0
2	0.7	22.0	55.0	109.0	66.0	6.10	2.74	2.74	12.566
3	0.7	22.0	55.0	109.0	66.0	6.90	2.00	2.00	25.133
4	0.7	22.0	55.0	109.0	66.0	7.75	1.10	1.10	50.265
5	0.7	22.0	56.0	110.0	66.0	8.40	0.42	0.42	100.531
6	0.7	22.0	56.0	110.0	66.0	8.70	0.24	0.24	150.796
7	0.7	22.0	56.0	110.0	66.0	8.80	0.14	0.14	201.062
8	0.7	22.0	56.0	110.0	66.0	8.80	0.09	0.09	248.186
9	0.7	22.0	56.0	111.0	66.0	8.90	0.00	0.00	**********

N	W*	F*	T*	P*/T*	W*T**.44	WF	WS	UP	UM	UU	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0	0.3164	0.9244	0.3423	0.0	3.753	0.0	217.65	72.66	75.21	0.064
2	0.1896	0.2573	0.9244	0.2784	0.1831	3.753	0.711	217.31	85.17	75.09	0.064
3	0.3239	0.1885	0.9244	0.2039	0.3129	3.753	1.216	216.91	93.99	74.95	0.064
4	0.4805	0.1041	0.9244	0.1127	0.4641	3.753	1.803	216.43	104.25	74.78	0.064
5	0.5943	0.0398	0.9228	0.0432	0.5737	3.749	2.228	216.23	111.73	74.72	0.064
6	0.6739	0.0228	0.9228	0.0247	0.6505	3.749	2.527	216.14	117.00	74.68	0.064
7	0.6863	0.0133	0.9228	0.0144	0.6624	3.749	2.573	216.09	117.80	74.67	0.064
8	0.6601	0.0081	0.9228	0.0098	0.6372	3.749	2.475	216.06	116.05	74.66	0.064
9	********	0.0005	0.9211	0.0005	********	3.749	*******	216.39	******	74.77	0.064

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION A

X/D:	-1.0	-0.5	0.0	0.5
-PMS(IN. H2O):	0.270	0.193	0.410	0.225
-PMS*:	0.026	0.018	0.039	0.021

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION B

X/D:	-1.0	-0.5	0.0	0.5
-PMS(IN. H2O):	0.210	0.170	0.380	0.230
-PMS*:	0.020	0.016	0.036	0.022

(g) S/D= 0.50; UPT Mach No.= 0.064

TABLE IX. Continued.

DATA TAKEN ON 3 AUGUST 1977 BY MIKE MOSS
4 NOZZLE; S/D=.5; L/D= 2.0; WITH TRANSITION

NUMBER OF PRIMARY NOZZLES: 4
PRIMARY NOZZLE DIAMETER: 3.38 INCHES
MIXING STACK LENGTH: 23.40 INCHES
MIXING STACK DIAMETER: 11.70 INCHES
MIXING STACK L/D: 2.00

UPTAKE DIAMETER: 11.50 INCHES
AREA RATIO, AM/AP: 3.00
ORIFICE DIAMETER: 6.902 INCHES
ORIFICE BETA: 0.497
AMBIENT PRESSURE: 29.92 INCHES HG

N	FOR	DPOR	TOR	TUPT	TAMB	PU-PA	PA-PS	PA-PNZ	SECONDARY AREA
RUN	INCHES OF WATER		DEGREES FAHRENHEIT			INCHES OF WATER			SQUARE INCHES
1	0.2	6.0	57.0	118.0	70.0	1.60	0.93	0.93	0.0
2	0.2	6.0	57.0	118.0	70.0	1.70	0.72	0.72	12.566
3	0.2	6.0	57.0	118.0	70.0	1.90	0.55	0.55	25.133
4	0.2	6.0	57.0	118.4	70.0	2.20	0.31	0.31	50.265
5	0.2	6.0	57.0	118.4	70.0	2.35	0.12	0.12	100.531
6	0.2	6.0	57.0	118.4	70.0	2.40	0.08	0.08	150.796
7	0.2	6.0	57.0	118.4	70.0	2.40	0.04	0.04	201.062
8	0.2	6.0	57.0	119.0	70.0	2.45	0.03	0.03	248.186
9	0.2	6.0	57.0	119.0	70.0	2.50	0.0	0.0	**********

N	W*	P*	T*	P*/T*	W*T**.44	WP	WS	UP	UM	UL	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0	0.3164	0.9169	0.3451	0.0	1.957	0.0	114.61	38.26	35.60	0.034
2	0.1856	0.2452	0.9169	0.2674	0.1787	1.957	0.363	114.55	44.74	35.58	0.034
3	0.3245	0.1875	0.9169	0.2044	0.3123	1.957	0.635	114.50	49.58	35.57	0.034
4	0.4872	0.1056	0.9163	0.1153	0.4688	1.957	0.954	114.52	55.28	35.57	0.034
5	0.5935	0.0392	0.9163	0.0428	0.5711	1.957	1.162	114.46	58.58	35.55	0.034
6	0.7425	0.0273	0.9163	0.0298	0.7145	1.957	1.453	114.45	64.20	35.55	0.034
7	0.7425	0.0154	0.9163	0.0168	0.7145	1.957	1.453	114.44	64.19	35.54	0.034
8	0.7484	0.0102	0.9153	0.0112	0.7198	1.957	1.465	114.56	64.43	35.58	0.034
9	********	0.0	0.9153	0.0	********	1.957	*******	114.55	******	35.58	0.034

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION A

X/D:	-1.0	-0.5	0.0	0.5
-PMS(IN. H2O):	0.075	0.055	0.115	0.070
-PMS*:	0.026	0.019	0.039	0.024

MIXING STACK PRESSURE DISTRIBUTION FOR RUN: 9 POSITION B

X/D:	-1.0	-0.5	0.0	0.5
-PMS(IN. H2O):	0.060	0.050	0.110	0.070
-PMS*:	0.020	0.017	0.037	0.024

(h) S/D= 0.50; UPT Mach No.= 0.034

TABLE IX. Continued.

DATA TAKEN ON 21 JUNE 1977 BY MIKE MOSS

4 NOZZLE: S/D=0.0: L/D= 3.0 ; MACH NO. = 0.063

AMBIENT PRESSURE = 29.820 IN.HGA, TEMPERATURE = 90.0 DEG.FAHR

PRIMARY (UPTAKE) TEMPERATURE = 129.0 DEG.FAHR

X	R	PTA	PTB	VA	VB	VA/VAV	VB/VAV
INCHES		IN.H2O		FT/SEC			
0.0	5.875	3.60	2.30	132.1	105.6	1.1099	0.8871
0.500	5.375	4.60	2.80	149.3	116.5	1.2546	0.9788
1.000	4.875	5.00	2.80	155.7	116.5	1.3080	0.9788
1.500	4.375	4.90	2.80	154.1	116.5	1.2949	0.9788
2.000	3.875	4.40	2.75	146.0	115.5	1.2270	0.9700
2.500	3.375	3.80	2.70	135.7	114.4	1.1403	0.9612
3.000	2.875	3.10	2.45	122.6	109.0	1.0299	0.9156
3.500	2.375	2.50	2.20	110.1	103.3	0.9249	0.8676
4.000	1.875	2.30	2.00	105.6	98.5	0.8871	0.8273
4.500	1.375	1.80	1.70	93.4	90.8	0.7848	0.7627
5.000	0.875	1.40	1.40	82.4	82.4	0.6921	0.6921
5.500	0.375	1.20	1.20	76.3	76.3	0.6408	0.6408
6.000	0.125	1.10	1.10	73.0	73.0	0.6135	0.6135
6.500	0.625	1.10	1.10	73.0	73.0	0.6135	0.6135
7.000	1.125	1.20	1.20	76.3	76.3	0.6408	0.6408
7.500	1.625	1.30	1.30	79.4	79.4	0.6670	0.6670
8.000	2.125	1.70	1.50	90.8	85.3	0.7627	0.7164
8.500	2.625	2.40	1.70	107.9	90.8	0.9062	0.7627
9.000	3.125	3.00	1.90	120.6	96.0	1.0132	0.8063
9.500	3.625	3.90	2.05	137.5	99.7	1.1552	0.8375
10.000	4.125	4.80	2.20	152.5	103.3	1.2816	0.8676
10.500	4.625	5.30	2.30	160.3	105.6	1.3467	0.8871
11.000	5.125	5.00	2.30	155.7	105.6	1.3080	0.8871
11.500	5.625	3.90	2.20	137.5	103.3	1.1552	0.8676
11.750	5.875	3.60	1.70	132.1	90.8	1.1099	0.7627

INTEGRATED FLOW RATE = 89.63 CU.FT/SEC
= 6.188 LBM/SEC

AVERAGE VELOCITY = 119.03 FT/SEC

PRIMARY FLOW RATE, WP = 3.689 LBM/SEC

PRIMARY VELOCITY, UP = 218.82 FT/SEC

MOMENTUM FACTOR, KM = 1.030

(a) S/D= 0.0; UPT Mach No.= 0.064

TABLE X. Tabulated Velocity Profile Data for L/D= 3
Without an Entrance Transition

DATA TAKEN ON 11 JULY 1977 BY MIKE MOSS

4 NOZZLE: S/D= .25: L/D= 3.0: MACH NO = 0.063

AMBIENT PRESSURE = 29.930 IN.HGA, TEMPERATURE = 66.0 DEG.FAHR

PRIMARY (UPTAKE) TEMPERATURE = 106.0 DEG.FAHR

X INCHES	R	PTA IN.H2O	PTB	VA FT/SEC	VB	VA/VAV	VB/VAV
0.0	5.875	2.10	1.80	98.6	91.3	0.8422	0.7797
0.500	5.375	2.70	2.00	111.8	96.2	0.9550	0.8219
1.000	4.875	3.10	2.30	119.8	103.2	1.0233	0.8814
1.500	4.375	3.80	2.60	132.7	109.7	1.1329	0.9371
2.000	3.875	3.90	2.70	134.4	111.8	1.1477	0.9550
2.500	3.375	4.30	3.10	141.1	119.8	1.2052	1.0233
3.000	2.875	4.20	3.30	139.5	123.6	1.1911	1.0558
3.500	2.375	3.80	3.40	132.7	125.5	1.1329	1.0716
4.000	1.875	3.60	3.10	129.1	119.8	1.1027	1.0233
4.500	1.375	3.20	2.90	121.7	115.9	1.0396	0.9897
5.000	0.875	2.90	2.60	115.9	109.7	0.9897	0.9371
5.500	0.375	2.70	2.40	111.8	105.4	0.9550	0.9004
6.000	0.125	2.50	2.30	107.6	103.2	0.9189	0.8814
6.500	0.625	2.40	2.40	105.4	105.4	0.9004	0.9004
7.000	1.125	2.50	2.60	107.6	109.7	0.9189	0.9371
7.500	1.625	2.70	2.70	111.8	111.8	0.9550	0.9550
8.000	2.125	3.00	2.80	117.9	113.9	1.0066	0.9725
8.500	2.625	3.60	2.80	129.1	113.9	1.1027	0.9725
9.000	3.125	4.40	2.60	142.8	109.7	1.2191	0.9371
9.500	3.625	4.90	2.30	150.7	103.2	1.2865	0.8814
10.000	4.125	5.30	2.00	156.7	96.2	1.3380	0.8219
10.500	4.625	4.90	1.70	150.7	88.7	1.2865	0.7578
11.000	5.125	4.10	1.60	137.8	86.1	1.1768	0.7351
11.500	5.625	3.40	1.40	125.5	80.5	1.0716	0.6877
11.750	5.875	3.00	1.20	117.9	74.6	1.0066	0.6367

INTEGRATED FLOW RATE = 88.18 CU.FT/SEC
= 6.372 LBM/SEC

AVERAGE VELOCITY = 117.10 FT/SEC

PRIMARY FLOW RATE, WP = 3.770 LBM/SEC

PRIMARY VELOCITY, UP = 214.06 FT/SEC

MOMENTUM FACTOR, KM = 1.018

(b) S/D= 0.25; UPT Mach No.= 0.064

TABLE X. Continued.

DATA TAKEN ON 11 JULY 1977 BY MIKE MOSS

4 NOZZLE: S/D= .25; L/D= 3.0; MACH NO = 0.034

AMBIENT PRESSURE = 29.930 IN.HGA, TEMPERATURE = 64.0 DEG.FAHR

PRIMARY (UPTAKE) TEMPERATURE = 115.0 DEG.FAHR

X (INCHES)	R (INCHES)	PTA (IN.H2O)	PTB (IN.H2O)	VA (FT/SEC)	VB (FT/SEC)	VA/VAV	VB/VAV
0.0	5.875	0.68	0.47	56.3	46.8	0.8841	0.7350
0.500	5.375	0.83	0.60	62.2	52.9	0.9768	0.8305
1.000	4.875	0.90	0.65	64.8	55.1	1.0171	0.8644
1.500	4.375	1.10	0.70	71.7	57.2	1.1245	0.8970
2.000	3.875	1.15	0.85	73.3	63.0	1.1498	0.9885
2.500	3.375	1.30	0.92	77.9	65.5	1.2225	1.0284
3.000	2.875	1.25	1.00	76.4	68.3	1.1987	1.0722
3.500	2.375	1.15	1.00	73.3	68.3	1.1498	1.0722
4.000	1.875	1.05	1.02	70.0	69.0	1.0986	1.0828
4.500	1.375	0.95	0.93	66.6	65.9	1.0450	1.0340
5.000	0.875	0.85	0.85	63.0	63.0	0.9885	0.9885
5.500	0.375	0.77	0.77	60.0	60.0	0.9408	0.9408
6.000	0.125	0.72	0.73	58.0	58.4	0.9098	0.9161
6.500	0.625	0.70	0.72	57.2	58.0	0.8970	0.9098
7.000	1.125	0.70	0.78	57.2	60.3	0.8970	0.9469
7.500	1.625	0.77	0.80	60.0	61.1	0.9408	0.9590
8.000	2.125	0.88	0.83	64.1	62.2	1.0058	0.9768
8.500	2.625	1.00	0.80	68.3	61.1	1.0722	0.9590
9.000	3.125	1.20	0.75	74.8	59.2	1.1745	0.9285
9.500	3.625	1.40	0.68	80.8	56.3	1.2686	0.8841
10.000	4.125	1.45	0.60	82.3	52.9	1.2911	0.8305
10.500	4.625	1.42	0.55	81.4	50.7	1.2776	0.7951
11.000	5.125	1.20	0.50	74.8	48.3	1.1745	0.7581
11.500	5.625	0.95	0.43	66.6	44.8	1.0450	0.7031
11.750	5.875	0.83	0.35	62.2	40.4	0.9768	0.6343

INTEGRATED FLOW RATE = 47.98 CU.FT/SEC
= 3.441 LBM/SEC

AVERAGE VELOCITY = 63.72 FT/SEC

PRIMARY FLOW RATE, WP = 1.970 LBM/SEC

PRIMARY VELOCITY, UP = 113.64 FT/SEC

MOMENTUM FACTOR, KM = 1.016

(c) S/D= 0.25; UPT Mach No.= 0.034

TABLE X. Continued.

DATA TAKEN ON 23 MAY 1977 BY MIKE MOSS

4 NOZZLE: S/D= 0.5; L/D= 3.0; MACH NO = 0.063

AMBIENT PRESSURE = 29.865 IN.HGA, TEMPERATURE = 84.0 DEG.FAHR

PRIMARY (UPTAKE) TEMPERATURE = 113.0 DEG.FAHR

X	R	PTA	PTB	VA	VB	VA/VAV	VB/VAV
INCHES		IN.H2O		FT/SEC			
0.0	5.875	3.20	1.90	123.2	94.9	0.9886	0.7618
0.500	5.375	4.20	2.40	141.1	106.7	1.1326	0.8562
1.000	4.875	4.70	2.60	149.3	111.0	1.1981	0.8911
1.500	4.375	5.10	2.80	155.5	115.2	1.2481	0.9248
2.000	3.875	5.40	3.15	160.0	122.2	1.2843	0.9809
2.500	3.375	5.00	3.30	154.0	125.1	1.2358	1.0040
3.000	2.875	4.60	3.60	147.7	130.6	1.1853	1.0486
3.500	2.375	4.10	3.80	139.4	134.2	1.1190	1.0773
4.000	1.875	3.70	3.60	132.4	130.6	1.0631	1.0486
4.500	1.375	3.50	3.40	128.8	127.0	1.0339	1.0191
5.000	0.875	3.20	3.20	123.2	123.2	0.9886	0.9886
5.500	0.375	3.10	3.10	121.2	121.2	0.9731	0.9731
6.000	0.125	3.00	3.00	119.3	119.3	0.9572	0.9572
6.500	0.625	3.10	3.15	121.2	122.2	0.9731	0.9809
7.000	1.125	3.40	3.33	127.0	125.6	1.0191	1.0085
7.500	1.625	3.80	3.40	134.2	127.0	1.0773	1.0191
8.000	2.125	4.30	3.30	142.8	125.1	1.1460	1.0040
8.500	2.625	4.80	3.00	150.8	119.3	1.2108	0.9572
9.000	3.125	5.20	2.70	157.0	113.1	1.2603	0.9081
9.500	3.625	5.10	2.35	155.5	105.5	1.2481	0.8472
10.000	4.125	4.50	2.00	146.1	97.4	1.1724	0.7816
10.500	4.625	3.90	1.90	136.0	94.9	1.0914	0.7618
11.000	5.125	3.40	1.60	127.0	87.1	1.0191	0.6991
11.500	5.625	2.40	1.40	106.7	81.5	0.8562	0.6539
11.750	5.875	2.40	1.30	106.7	78.5	0.8562	0.6301

INTEGRATED FLOW RATE = 93.81 CU.FT/SEC
= 6.624 LBM/SEC

AVERAGE VELOCITY = 124.59 FT/SEC

PRIMARY FLOW RATE, WP = 3.712 LBM/SEC

PRIMARY VELOCITY, UP = 213.89 FT/SEC

MOMENTUM FACTOR, KM = 1.021

(d) S/D= 0.5; UPT Mach No.= 0.064

TABLE X. Continued.

OATA TAKEN ON 9 JUNE 1977 BY MIKE MOSS

4 NOZZLE: S/D= .75: L/D= 3.0: MACH NO = 0.063

AMBIENT PRESSURE = 29.890 IN.HGA, TEMPERATURE = 72.0 DEG.FAHR

PRIMARY (UPTAKE) TEMPERATURE = 108.0 DEG.FAHR

X (INCHES)	R (INCHES)	PTA (IN.H2O)	PTB (IN.H2O)	VA (FT/SEC)	VB (FT/SEC)	VA/VAV	VB/VAV
0.0	5.875	3.70	2.00	131.4	96.6	1.0243	0.7531
0.500	5.375	4.40	2.60	143.3	110.2	1.1170	0.8586
1.000	4.875	4.90	2.80	151.3	114.3	1.1787	0.8910
1.500	4.375	4.90	3.00	151.3	118.4	1.1787	0.9223
2.000	3.875	4.90	3.30	151.3	124.1	1.1787	0.9673
2.500	3.375	4.90	3.50	151.3	127.8	1.1787	0.9962
3.000	2.875	4.70	3.80	148.1	133.2	1.1544	1.0380
3.500	2.375	4.50	4.00	145.0	136.7	1.1296	1.0650
4.000	1.875	4.30	4.10	141.7	138.4	1.1042	1.0782
4.500	1.375	4.20	4.00	140.0	136.7	1.0913	1.0650
5.000	0.875	4.00	3.90	136.7	134.9	1.0650	1.0516
5.500	0.375	3.90	3.80	134.9	133.2	1.0516	1.0380
6.000	0.125	3.80	3.80	133.2	133.2	1.0380	1.0380
6.500	0.625	3.80	3.80	133.2	133.2	1.0380	1.0380
7.000	1.125	4.00	3.80	136.7	133.2	1.0650	1.0380
7.500	1.625	4.10	3.75	138.4	132.3	1.0782	1.0312
8.000	2.125	4.30	3.60	141.7	129.7	1.1042	1.0103
8.500	2.625	4.70	3.25	148.1	123.2	1.1544	0.9600
9.000	3.125	4.90	3.00	151.3	118.4	1.1787	0.9223
9.500	3.625	5.00	2.60	152.8	110.2	1.1907	0.8586
10.000	4.125	4.90	2.30	151.3	103.6	1.1787	0.8076
10.500	4.625	4.30	2.10	141.7	99.0	1.1042	0.7717
11.000	5.125	3.70	2.00	131.4	96.6	1.0243	0.7531
11.500	5.625	3.00	1.60	118.4	86.4	0.9223	0.6736
11.750	5.875	3.00	1.60	118.4	86.4	0.9223	0.6736

INTEGRATED FLOW RATE = 96.63 CU.FT/SEC
= 6.927 LBM/SEC

AVERAGE VELOCITY = 128.33 FT/SEC

PRIMARY FLOW RATE, WP = 3.763 LBM/SEC

PRIMARY VELOCITY, UP = 214.75 FT/SEC

MOMENTUM FACTOR, KM = 1.015

(e) S/D= 0.75; UPT Mach No.= 0.064

TABLE X. Continued.

DATA TAKEN ON 9 JUNE 1977 BY MIKE MOSS

4 NOZZLE: S/D= .75; L/D= 3.0; MACH NO = 0.034

AMBIENT PRESSURE = 29.890 IN.HGA, TEMPERATURE = 70.0 DEG.FAHR

PRIMARY (UPTAKE) TEMPERATURE = 116.0 DEG.FAHR

X	R	PTA	PTB	VA	VB	VA/VAV	VB/VAV
INCHES		IN.H2O		FT/SEC			
0.0	5.875	0.95	0.53	66.8	49.9	1.0150	0.7581
0.500	5.375	1.15	0.66	73.5	55.7	1.1168	0.8460
1.000	4.875	1.25	0.73	76.7	58.6	1.1643	0.8898
1.500	4.375	1.30	0.78	78.2	60.6	1.1874	0.9197
2.000	3.875	1.30	0.82	78.2	62.1	1.1874	0.9430
2.500	3.375	1.25	0.88	76.7	64.3	1.1643	0.9769
3.000	2.875	1.20	0.95	75.1	66.8	1.1408	1.0150
3.500	2.375	1.15	1.00	73.5	68.6	1.1168	1.0414
4.000	1.875	1.12	1.05	72.6	70.3	1.1021	1.0671
4.500	1.375	1.10	1.05	71.9	70.3	1.0922	1.0671
5.000	0.875	1.05	1.03	70.3	69.6	1.0671	1.0569
5.500	0.375	1.02	1.01	69.2	68.9	1.0517	1.0466
6.000	0.125	1.02	1.01	69.2	68.9	1.0517	1.0466
6.500	0.625	1.02	1.02	69.2	69.2	1.0517	1.0517
7.000	1.125	1.07	1.02	70.9	69.2	1.0772	1.0517
7.500	1.625	1.10	1.01	71.9	68.9	1.0922	1.0466
8.000	2.125	1.15	0.97	73.5	67.5	1.1168	1.0256
8.500	2.625	1.22	0.88	75.7	64.3	1.1502	0.9769
9.000	3.125	1.28	0.80	77.6	61.3	1.1782	0.9314
9.500	3.625	1.30	0.73	78.2	58.6	1.1874	0.8898
10.000	4.125	1.27	0.63	77.3	54.4	1.1736	0.8266
10.500	4.625	1.18	0.55	74.5	50.8	1.1312	0.7723
11.000	5.125	1.00	0.53	68.6	49.9	1.0414	0.7581
11.500	5.625	0.75	0.43	59.4	45.0	0.9019	0.6829
11.750	5.875	0.75	0.40	59.4	43.4	0.9019	0.6586

INTEGRATED FLOW RATE = 49.58 CU.FT/SEC
= 3.530 LBM/SEC

AVERAGE VELOCITY = 65.84 FT/SEC

PRIMARY FLOW RATE, WP = 1.965 LBM/SEC

PRIMARY VELOCITY, UP = 113.69 FT/SEC

MOMENTUM FACTOR, KM = 1.015

(f) S/D= 0.75; UPT Mach No.= 0.034

TABLE X. Continued.

DATA TAKEN ON 12 JULY 1977 BY MIKE MOSS

4 NOZZLE: S/D= 1.0; L/D= 3.0; MACH NO = 0.063

AMBIENT PRESSURE = 29.910 IN.HGA, TEMPERATURE = 70.0 DEG.FAHR

PRIMARY (UPTAKE) TEMPERATURE = 107.0 DEG.FAHR

X (INCHES)	R (INCHES)	PTA (IN.H2O)	PTB (IN.H2O)	VA (FT/SEC)	VB (FT/SEC)	VA/VAV	VB/VAV
0.0	5.875	3.10	1.90	120.1	94.0	0.9968	0.7804
0.500	5.375	3.60	2.20	129.4	101.2	1.0742	0.8397
1.000	4.875	4.00	2.40	136.4	105.7	1.1323	0.8770
1.500	4.375	4.10	2.50	138.1	107.9	1.1463	0.8951
2.000	3.875	4.10	2.70	138.1	112.1	1.1463	0.9302
2.500	3.375	4.00	2.80	136.4	114.2	1.1323	0.9473
3.000	2.875	3.90	3.00	134.7	118.2	1.1180	0.9806
3.500	2.375	3.75	3.25	132.1	123.0	1.0963	1.0206
4.000	1.875	3.65	3.35	130.3	124.9	1.0816	1.0362
4.500	1.375	3.55	3.40	128.5	125.8	1.0667	1.0439
5.000	0.875	3.50	3.50	127.6	127.6	1.0591	1.0591
5.500	0.375	3.50	3.50	127.6	127.6	1.0591	1.0591
6.000	0.125	3.50	3.50	127.6	127.6	1.0591	1.0591
6.500	0.625	3.55	3.50	128.5	127.6	1.0667	1.0591
7.000	1.125	3.60	3.50	129.4	127.6	1.0742	1.0591
7.500	1.625	3.65	3.40	130.3	125.8	1.0816	1.0439
8.000	2.125	3.80	3.30	133.0	123.9	1.1036	1.0284
8.500	2.625	3.84	3.10	133.7	120.1	1.1094	0.9968
9.000	3.125	3.90	2.85	134.7	115.2	1.1180	0.9557
9.500	3.625	4.00	2.65	136.4	111.1	1.1323	0.9216
10.000	4.125	3.85	2.50	133.9	107.9	1.1108	0.8951
10.500	4.625	3.75	2.40	132.1	105.7	1.0963	0.8770
11.000	5.125	3.40	2.20	125.8	101.2	1.0439	0.8397
11.500	5.625	3.00	2.00	118.2	96.5	0.9806	0.8006
11.750	5.875	2.20	1.60	101.2	86.3	0.8397	0.7161

INTEGRATED FLOW RATE = 90.74 CU.FT/SEC
= 6.526 LBM/SEC

AVERAGE VELOCITY = 120.51 FT/SEC

PRIMARY FLOW RATE, WP = 3.761 LBM/SEC

PRIMARY VELOCITY, UP = 214.09 FT/SEC

MOMENTUM FACTOR, KM = 1.008

(g) S/D= 1.0; UPT Mach No.= 0.064

TABLE X. Continued.

DATA TAKEN ON 1 AUGUST 1977 BY MIKE MOSS

+ NOZZLE: S/D= -.25; L/D= 3.0; WITH TRANSITION; MACH NO.= .063

AMBIENT PRESSURE = 29.900 IN.HGA, TEMPERATURE = 75.0 DEG.FAHR

PRIMARY (UPTAKE) TEMPERATURE = 114.0 DEG.FAHR

X (INCHES)	R (INCHES)	PTA (IN.H2O)	PTB (IN.H2O)	VA (FT/SEC)	VB (FT/SEC)	VA/VAV	VB/VAV
0.0	5.875	2.00	0.50	97.0	48.5	0.7918	0.3959
0.500	5.375	2.50	0.90	108.5	65.1	0.8852	0.5311
1.000	4.875	3.50	1.10	128.4	72.0	1.0474	0.5872
1.500	4.375	4.40	1.50	143.9	84.0	1.1744	0.6857
2.000	3.875	5.70	1.80	163.8	92.1	1.3366	0.7511
2.500	3.375	6.30	2.30	172.2	104.1	1.4052	0.8491
3.000	2.875	6.50	3.00	174.9	118.8	1.4273	0.9697
3.500	2.375	6.20	3.50	170.8	128.4	1.3940	1.0474
4.000	1.875	5.50	3.90	160.9	135.5	1.3130	1.1056
4.500	1.375	4.90	4.10	151.9	138.9	1.2393	1.1336
5.000	0.875	4.50	4.10	145.6	138.9	1.1876	1.1336
5.500	0.375	4.00	3.80	137.2	133.8	1.1197	1.0914
6.000	0.125	3.80	3.70	133.8	132.0	1.0914	1.0769
6.500	0.625	3.30	3.40	124.6	126.5	1.0170	1.0323
7.000	1.125	3.20	3.30	122.7	124.6	1.0015	1.0170
7.500	1.625	3.30	3.30	124.6	124.6	1.0170	1.0170
8.000	2.125	3.50	3.30	128.4	124.6	1.0474	1.0170
8.500	2.625	4.30	3.40	142.3	126.5	1.1609	1.0323
9.000	3.125	5.30	3.30	158.0	124.6	1.2889	1.0170
9.500	3.625	6.20	3.00	170.8	118.8	1.3940	0.9697
10.000	4.125	6.70	2.40	177.6	106.3	1.4491	0.8673
10.500	4.625	6.10	1.90	169.5	94.6	1.3827	0.7717
11.000	5.125	4.80	1.40	150.3	81.2	1.2266	0.6624
11.500	5.625	3.60	1.00	130.2	68.6	1.0622	0.5599
11.750	5.875	3.30	0.70	124.6	57.4	1.0170	0.4684

INTEGRATED FLOW RATE = 92.29 CU.FT/SEC
= 6.561 LBM/SEC

AVERAGE VELOCITY = 122.56 FT/SEC

PRIMARY FLOW RATE, WP = 3.735 LBM/SEC

PRIMARY VELOCITY, UP = 215.31 FT/SEC

MOMENTUM FACTOR, KM = 1.053

(a) S/D= -0.25; UPT Mach No.= 0.064

TABLE XI. Tabulated Velocity Profile Data for L/D= 3 with an Entrance Transition

DATA TAKEN ON 1 AUGUST 1977 BY MIKE MOSS

4 NOZZLE: S/D= 0.0: L/D= 3.0: WITH TRANSITION: MACH NO. = 0.063

AMBIENT PRESSURE = 29.900 IN.HGA, TEMPERATURE = 95.0 DEG.FAHR

PRIMARY (UPTAKE) TEMPERATURE = 133.0 DEG.FAHR

X INCHES	R	PTA IN.H2O	PTB	VA FT/SEC	VB	VA/VAV	VB/VAV
0.0	5.875	2.20	1.10	103.5	73.2	0.8263	0.5843
0.500	5.375	2.60	1.20	112.5	76.5	0.8982	0.6102
1.000	4.875	2.80	1.30	116.8	79.6	0.9322	0.6352
1.500	4.375	4.30	1.50	144.7	85.5	1.1552	0.6823
2.000	3.875	5.30	1.90	160.7	96.2	1.2825	0.7679
2.500	3.375	5.60	2.30	165.2	105.9	1.3183	0.8448
3.000	2.875	6.00	3.00	171.0	120.9	1.3645	0.9649
3.500	2.375	5.90	3.60	169.5	132.4	1.3531	1.0570
4.000	1.875	5.50	4.20	163.7	143.0	1.3064	1.1416
4.500	1.375	5.10	4.40	157.6	146.4	1.2580	1.1685
5.000	0.875	4.60	4.60	149.7	149.7	1.1948	1.1948
5.500	0.375	4.40	4.50	146.4	148.1	1.1685	1.1817
6.000	0.125	4.10	4.30	141.3	144.7	1.1280	1.1552
6.500	0.625	3.80	4.10	136.1	141.3	1.0859	1.1280
7.000	1.125	3.60	3.90	132.4	137.8	1.0570	1.1001
7.500	1.625	3.50	3.80	130.6	136.1	1.0422	1.0859
8.000	2.125	3.80	3.60	136.1	132.4	1.0859	1.0570
8.500	2.625	4.20	3.50	143.0	130.6	1.1416	1.0422
9.000	3.125	5.00	3.30	156.1	126.8	1.2456	1.0120
9.500	3.625	5.80	2.90	168.1	118.9	1.3416	0.9487
10.000	4.125	6.10	2.40	172.4	108.1	1.3759	0.8630
10.500	4.625	5.90	2.00	169.5	98.7	1.3531	0.7878
11.000	5.125	4.70	1.50	151.3	85.5	1.2077	0.6823
11.500	5.625	3.60	1.20	132.4	76.5	1.0570	0.6102
11.750	5.875	3.20	0.90	124.9	66.2	0.9965	0.5285

INTEGRATED FLOW RATE = 94.35 CU.FT/SEC
= 6.482 LBM/SEC

AVERAGE VELOCITY = 125.30 FT/SEC

PRIMARY FLOW RATE, WP = 3.687 LBM/SEC

PRIMARY VELOCITY, UP = 219.60 FT/SEC

MOMENTUM FACTOR, KM = 1.042

(b) S/D= 0.0; UPT Mach No.= 0.064

TABLE XI. Continued.

DATA TAKEN ON 2 AUGUST 1977 BY MIKE MOSS

4 NOZZLE: S/D= .25: L/D=3.0: WITH TRANSITION: MACH NO. = .063

AMBIENT PRESSURE = 29.930 IN.HGA, TEMPERATURE = 72.0 DEG.FAHR

PRIMARY (UPTAKE) TEMPERATURE = 112.0 DEG.FAHR

X INCHES	R	PTA IN.H2O	PTB	VA FT/SEC	VB	VA/VAV	VB/VAV
0.0	5.875	2.50	1.30	108.2	78.0	0.8706	0.6278
0.500	5.375	3.50	1.20	128.0	75.0	1.0301	0.6032
1.000	4.875	4.10	1.40	138.6	81.0	1.1149	0.6515
1.500	4.375	4.60	1.80	146.8	91.8	1.1809	0.7387
2.000	3.875	5.00	2.00	153.0	96.8	1.2312	0.7787
2.500	3.375	5.20	2.80	156.0	114.5	1.2556	0.9214
3.000	2.875	5.20	3.30	156.0	124.3	1.2556	1.0002
3.500	2.375	5.00	3.90	153.0	135.1	1.2312	1.0874
4.000	1.875	4.85	4.25	150.7	141.1	1.2126	1.1351
4.500	1.375	4.70	4.50	148.4	145.2	1.1937	1.1680
5.000	0.875	4.50	4.60	145.2	146.8	1.1680	1.1809
5.500	0.375	4.30	4.40	141.9	143.5	1.1418	1.1550
6.000	0.125	4.00	4.20	136.9	140.2	1.1012	1.1284
6.500	0.625	3.90	4.00	135.1	136.9	1.0874	1.1012
7.000	1.125	3.80	3.90	133.4	135.1	1.0733	1.0874
7.500	1.625	4.00	3.90	136.9	135.1	1.1012	1.0874
8.000	2.125	4.20	3.80	140.2	133.4	1.1284	1.0733
8.500	2.625	4.60	3.60	146.8	129.8	1.1809	1.0447
9.000	3.125	5.00	3.30	153.0	124.3	1.2312	1.0002
9.500	3.625	5.35	2.90	158.3	116.5	1.2736	0.9377
10.000	4.125	5.25	2.50	156.8	108.2	1.2616	0.8706
10.500	4.625	4.80	2.00	149.9	96.8	1.2063	0.7787
11.000	5.125	4.10	1.80	138.6	91.8	1.1149	0.7387
11.500	5.625	3.30	1.60	124.3	86.6	1.0002	0.6965
11.750	5.875	2.70	1.20	112.4	75.0	0.9048	0.6032

INTEGRATED FLOW RATE = 93.58 CU.FT/SEC
= 6.689 LBM/SEC

AVERAGE VELOCITY = 124.28 FT/SEC

PRIMARY FLOW RATE, WP = 3.746 LBM/SEC

PRIMARY VELOCITY, UP = 214.97 FT/SEC

MOMENTUM FACTOR, KM = 1.029

(c) S/D= 0.25; UPT Mach No.= 0.064

TABLE XI. Continued.

DATA TAKEN ON 2 AUGUST 1977 BY MIKE MOSS

4 NOZZLE: S/D= .25; L/D=3.0; WITH TRANSITION; MACH NO. = .033

AMBIENT PRESSURE = 29.930 IN.HGA, TEMPERATURE = 80.0 DEG.FAHR

PRIMARY (UPTAKE) TEMPERATURE = 124.0 DEG.FAHR

X INCHES	R	PTA IN.H2O	PTB	VA FT/SEC	VB	VA/VAV	VB/VAV
0.0	5.875	0.65	0.33	55.7	39.7	0.8453	0.6023
0.500	5.375	0.73	0.35	59.0	40.9	0.8958	0.6203
1.000	4.875	0.93	0.42	66.6	44.8	1.0111	0.6795
1.500	4.375	1.15	0.50	74.1	48.8	1.1243	0.7414
2.000	3.875	1.25	0.57	77.2	52.1	1.1722	0.7916
2.500	3.375	1.40	0.73	81.7	59.0	1.2406	0.8958
3.000	2.875	1.45	0.88	83.2	64.8	1.2625	0.9835
3.500	2.375	1.45	1.00	83.2	69.1	1.2625	1.0485
4.000	1.875	1.33	1.13	79.6	73.4	1.2091	1.1145
4.500	1.375	1.30	1.17	78.7	74.7	1.1954	1.1341
5.000	0.875	1.25	1.27	77.2	77.8	1.1722	1.1816
5.500	0.375	1.22	1.25	76.3	77.2	1.1581	1.1722
6.000	0.125	1.18	1.20	75.0	75.7	1.1389	1.1485
6.500	0.625	1.15	1.18	74.1	75.0	1.1243	1.1389
7.000	1.125	1.12	1.16	73.1	74.4	1.1096	1.1292
7.500	1.625	1.10	1.16	72.4	74.4	1.0996	1.1292
8.000	2.125	1.22	1.14	76.3	73.7	1.1581	1.1194
8.500	2.625	1.28	1.10	78.1	72.4	1.1862	1.0996
9.000	3.125	1.38	1.00	81.1	69.1	1.2317	1.0485
9.500	3.625	1.46	0.90	83.4	65.5	1.2669	0.9947
10.000	4.125	1.47	0.75	83.7	59.8	1.2712	0.9080
10.500	4.625	1.33	0.63	79.6	54.8	1.2091	0.8322
11.000	5.125	1.13	0.55	73.4	51.2	1.1145	0.7776
11.500	5.625	0.93	0.47	66.6	47.3	1.0111	0.7188
11.750	5.875	0.77	0.35	60.6	40.9	0.9200	0.6203

INTEGRATED FLOW RATE = 49.60 CU.FT/SEC
= 3.481 LBM/SEC

AVERAGE VELOCITY = 65.87 FT/SEC

PRIMARY FLOW RATE, WP = 1.949 LBM/SEC

PRIMARY VELOCITY, UP = 114.20 FT/SEC

MOMENTUM FACTOR, KM = 1.029

(d) S/D= 0.25; UPT Mach No.= 0.034

TABLE XI. Continued.

OATA TAKEN ON 2 AUGUST 1977 8Y MIKE MOSS

4 NOZZLE: S/D= .5: L/D= 3.0: WITH TRANSITION: MACH NO. = .063

AMBIENT PRESSURE = 29.930 IN.HGA, TEMPERATURE = 90.0 DEG.FAHR

PRIMARY (UPTAKE) TEMPERATURE = 119.0 DEG.FAHR

X INCHES	R	PTA IN.H2O	PTB	VA FT/SEC	VB	VA/VAV	VB/VAV
0.0	5.875	2.70	1.40	113.6	81.8	0.8997	0.6479
0.500	5.375	3.40	1.70	127.5	90.2	1.0096	0.7139
1.000	4.875	4.10	2.00	140.0	97.8	1.1087	0.7744
1.500	4.375	4.40	2.40	145.0	107.1	1.1486	0.8483
2.000	3.875	4.80	2.90	151.5	117.8	1.1996	0.9324
2.500	3.375	5.00	3.30	154.6	125.6	1.2244	0.9947
3.000	2.875	5.00	3.50	154.6	129.4	1.2244	1.0244
3.500	2.375	4.95	4.00	153.8	138.3	1.2182	1.0951
4.000	1.875	4.80	4.40	151.5	145.0	1.1996	1.1486
4.500	1.375	4.70	4.50	149.9	146.7	1.1871	1.1615
5.000	0.875	4.50	4.50	146.7	146.7	1.1615	1.1615
5.500	0.375	4.30	4.40	143.4	145.0	1.1354	1.1486
6.000	0.125	4.10	4.20	140.0	141.7	1.1087	1.1221
6.500	0.625	4.00	4.10	138.3	140.0	1.0951	1.1087
7.000	1.125	4.00	4.00	138.3	138.3	1.0951	1.0951
7.500	1.625	4.10	3.90	140.0	136.6	1.1087	1.0813
8.000	2.125	4.30	3.60	143.4	131.2	1.1354	1.0389
8.500	2.625	4.60	3.40	148.3	127.5	1.1744	1.0096
9.000	3.125	4.90	3.00	153.1	119.8	1.2121	0.9484
9.500	3.625	4.95	2.60	153.8	111.5	1.2182	0.8829
10.000	4.125	4.75	2.30	150.7	104.9	1.1934	0.8304
10.500	4.625	4.30	2.00	143.4	97.8	1.1354	0.7744
11.000	5.125	3.75	1.85	133.9	94.0	1.0603	0.7448
11.500	5.625	3.10	1.60	121.7	87.5	0.9641	0.6926
11.750	5.875	2.80	1.20	115.7	75.7	0.9162	0.5998

INTEGRATED FLOW RATE = 95.09 CU.FT/SEC
= 6.657 LBM/SEC

AVERAGE VELOCITY = 126.28 FT/SEC

PRIMARY FLOW RATE, WP = 3.725 LBM/SEC

PRIMARY VELOCITY, UP = 216.38 FT/SEC

MOMENTUM FACTOR, KM = 1.022

(e) S/D= 0.50; UPT Mach No.= 0.064

TABLE XI. Continued.

DATA TAKEN ON 14 JULY 1977 BY MIKE MOSS

4 NOZZLE: S/D= 0.00; L/D= 2.0; MACH NO. = 0.063

AMBIENT PRESSURE = 29.900 IN.HGA. TEMPERATURE = 66.0 DEG.FAHR

PRIMARY (UPTAKE) TEMPERATURE = 106.0 DEG.FAHR

X	R	PTA	PTB	VA	VB	VA/VAV	VB/VAV
INCHES		IN.H2O		FT/SEC			
0.0	5.875	2.90	0.65	116.0	54.9	1.1366	0.5381
0.500	5.375	3.50	0.70	127.4	57.0	1.2487	0.5584
1.000	4.875	4.40	0.80	142.8	60.9	1.4001	0.5970
1.500	4.375	5.80	1.00	164.0	68.1	1.6075	0.6675
2.000	3.875	5.60	1.20	161.1	74.6	1.5795	0.7312
2.500	3.375	4.10	1.50	137.9	83.4	1.3515	0.8175
3.000	2.875	3.00	1.60	117.9	86.1	1.1561	0.8443
3.500	2.375	2.30	1.40	103.3	80.6	1.0123	0.7898
4.000	1.875	1.80	1.10	91.4	71.4	0.8955	0.7000
4.500	1.375	1.50	0.90	83.4	64.6	0.8175	0.6332
5.000	0.875	1.00	0.65	68.1	54.9	0.6675	0.5381
5.500	0.375	0.50	0.50	48.1	48.1	0.4720	0.4720
6.000	0.125	0.45	0.45	45.7	45.7	0.4477	0.4477
6.500	0.625	0.40	0.40	43.1	43.1	0.4221	0.4221
7.000	1.125	0.40	0.55	43.1	50.5	0.4221	0.4950
7.500	1.625	0.50	0.75	48.1	59.0	0.4720	0.5780
[illegible].000	2.125	0.75	1.10	59.0	71.4	0.5780	0.7000
[illegible].500	2.625	1.30	1.40	77.6	80.6	0.7610	0.7898
9.000	3.125	2.20	1.70	101.0	88.8	0.9900	0.8703
9.500	3.625	3.40	1.85	125.6	92.6	1.2307	0.9078
10.000	4.125	5.00	1.75	152.3	90.1	1.4925	0.8830
10.500	4.625	6.30	1.70	170.9	88.8	1.6753	0.8703
11.000	5.125	6.10	1.60	168.2	86.1	1.6485	0.8443
11.500	5.625	4.60	1.50	146.0	83.4	1.4315	0.8175
11.750	5.875	3.00	1.20	117.9	74.6	1.1561	0.7312

INTEGRATED FLOW RATE = 76.82 CU.FT/SEC
= 5.546 LBM/SEC

AVERAGE VELOCITY = 102.02 FT/SEC

PRIMARY FLOW RATE, WP = 3.776 LBM/SEC

PRIMARY VELOCITY, UP = 214.66 FT/SEC

MOMENTUM FACTOR, KM = 1.088

(a) S/D= 0; UPT Mach No.= 0.064

TABLE XII. Tabulated Velocity Profile Data for L/D= 2
Without an Entrance Transition

DATA TAKEN ON 14 JULY 1977 BY MIKE MOSS

4 NOZZLE: S/D= 0.25; L/D= 2.0; MACH NO. = 0.063

AMBIENT PRESSURE = 29.900 IN.HGA, TEMPERATURE = 66.0 DEG.FAHR

PRIMARY (UPTAKE) TEMPERATURE = 106.0 DEG.FAHR

X	R	PTA	PTB	VA	VB	VA/VAV	VB/VAV
INCHES		IN.H2O		FT/SEC			
0.0	5.875	1.90	0.35	93.9	40.3	0.8466	0.3634
0.500	5.375	2.00	0.50	96.3	48.1	0.8686	0.4343
1.000	4.875	2.90	0.60	116.0	52.7	1.0460	0.4758
1.500	4.375	4.80	0.90	149.2	64.6	1.3457	0.5827
2.000	3.875	6.00	1.30	166.8	77.6	1.5045	0.7003
2.500	3.375	6.60	1.80	174.9	91.4	1.5779	0.8240
3.000	2.875	5.80	2.10	164.0	98.7	1.4792	0.8901
3.500	2.375	4.70	2.90	147.6	116.0	1.3316	1.0460
4.000	1.875	3.60	2.80	129.2	113.9	1.1654	1.0278
4.500	1.375	3.10	2.80	119.9	113.9	1.0814	1.0278
5.000	0.875	2.60	2.40	109.8	105.5	0.9904	0.9515
5.500	0.375	2.00	2.20	96.3	101.0	0.8686	0.9110
6.000	0.125	1.70	1.80	88.8	91.4	0.8008	0.8240
6.500	0.625	1.40	1.70	80.6	88.8	0.7267	0.8008
7.000	1.125	1.40	1.70	80.6	88.8	0.7267	0.8008
7.500	1.625	1.80	2.10	91.4	98.7	0.8240	0.8901
8.000	2.125	2.80	2.50	113.9	107.7	1.0278	0.9711
8.500	2.625	3.50	3.00	127.4	117.9	1.1491	1.0638
9.000	3.125	4.70	3.10	147.6	119.9	1.3316	1.0814
9.500	3.625	6.00	3.00	166.8	117.9	1.5045	1.0638
10.000	4.125	6.30	2.50	170.9	107.7	1.5416	0.9711
10.500	4.625	5.30	1.90	156.8	93.9	1.4140	0.8466
11.000	5.125	3.90	1.40	134.5	80.6	1.2130	0.7267
11.500	5.625	2.80	1.10	113.9	71.4	1.0278	0.6442
11.750	5.875	2.40	0.80	105.5	60.9	0.9515	0.5494

INTEGRATED FLOW RATE = 83.48 CU.FT/SEC
= 6.026 LBM/SEC

AVERAGE VELOCITY = 110.86 FT/SEC

PRIMARY FLOW RATE, WP = 3.768 LBM/SEC

PRIMARY VELOCITY, UP = 214.18 FT/SEC

MOMENTUM FACTOR, KM = 1.070

(b) S/D= 0.25; UPT Mach No.= 0.063

TABLE XII. Continued.

DATA TAKEN ON 14 JULY 1977 BY MIKE MOSS

4 NOZZLE: S/D= 0.25: L/D= 2.0: MACH NO. = 0.034

AMBIENT PRESSURE = 29.900 IN.HGA, TEMPERATURE = 66.0 DEG.FAHR

PRIMARY (UPTAKE) TEMPERATURE = 116.0 DEG.FAHR

X INCHES	R	PTA IN.H2O	PTB	VA FT/SEC	VB	VA/VAV	VB/VAV
0.0	5.875	0.50	0.08	48.4	19.4	0.7935	0.3174
0.500	5.375	0.65	0.11	55.2	22.7	0.9047	0.3722
1.000	4.875	0.95	0.15	66.7	26.5	1.0937	0.4346
1.500	4.375	1.30	0.25	78.0	34.2	1.2794	0.5611
2.000	3.875	1.85	0.37	93.1	41.6	1.5263	0.6826
2.500	3.375	1.95	0.52	95.6	49.4	1.5670	0.8092
3.000	2.875	1.70	0.65	89.2	55.2	1.4631	0.9047
3.500	2.375	1.40	0.77	81.0	60.1	1.3277	0.9847
4.000	1.875	1.15	0.80	73.4	61.2	1.2033	1.0037
4.500	1.375	0.95	0.75	66.7	59.3	1.0937	0.9718
5.000	0.875	0.80	0.70	61.2	57.3	1.0037	0.9388
5.500	0.375	0.60	0.63	53.0	54.3	0.8692	0.8907
6.000	0.125	0.50	0.55	48.4	50.8	0.7935	0.8322
6.500	0.625	0.45	0.48	45.9	47.4	0.7527	0.7774
7.000	1.125	0.47	0.50	46.9	48.4	0.7693	0.7935
7.500	1.625	0.60	0.60	53.0	53.0	0.8692	0.8692
8.000	2.125	0.88	0.75	64.2	59.3	1.0526	0.9718
8.500	2.625	1.20	0.85	75.0	63.1	1.2292	1.0346
9.000	3.125	1.60	0.87	86.6	63.8	1.4194	1.0467
9.500	3.625	1.95	0.80	95.6	61.2	1.5670	1.0037
10.000	4.125	2.05	0.67	98.0	56.0	1.6066	0.9185
10.500	4.625	1.70	0.52	89.2	49.4	1.4631	0.8092
11.000	5.125	1.25	0.40	76.5	43.3	1.2546	0.7097
11.500	5.625	0.88	0.33	64.2	39.3	1.0526	0.6446
11.750	5.875	0.80	0.25	61.2	34.2	1.0037	0.5611

INTEGRATED FLOW RATE = 45.93 CU.FT/SEC
= 3.282 LBM/SEC

AVERAGE VELOCITY = 60.99 FT/SEC

PRIMARY FLOW RATE, WP = 1.967 LBM/SEC

PRIMARY VELOCITY, UP = 113.78 FT/SEC

MOMENTUM FACTOR, KM = 1.077

(c) S/D= 0.25; UPT Mach No.= 0.034

TABLE XII. Continued.

OATA TAKEN ON 15 JULY 1977 BY M*KE MOSS

4 NOZZLE: S/O= 0.50; L/O= 2.0; MACH NO. = 0.063

AMBIENT PRESSURE = 29.910 IN.HGA, TEMPERATURE = 66.0 DEG.FAHR

PRIMARY (UPTAKE) TEMPERATURE = 105.0 DEG.FAHR

X	R	PTA	PTB	VA	VB	VA/VAV	VB/VAV
INCHES		IN.H2O		FT/SEC			
0.0	5.875	2.90	0.90	115.9	64.6	0.9503	0.5294
0.500	5.375	4.10	1.10	137.8	71.4	1.1299	0.5852
1.000	4.875	5.40	1.35	158.1	79.1	1.2967	0.6483
1.500	4.375	6.60	1.50	174.8	83.3	1.4336	0.6834
2.000	3.875	6.90	2.00	178.7	96.2	1.4658	0.7891
2.500	3.375	6.40	2.50	172.1	107.6	1.4117	0.8823
3.000	2.875	5.70	3.00	162.5	117.9	1.3322	0.9665
3.500	2.375	4.80	3.30	149.1	123.6	1.2225	1.0137
4.000	1.875	4.10	3.65	137.8	130.0	1.1299	1.0661
4.500	1.375	3.30	3.45	123.6	126.4	1.0137	1.0365
5.000	0.875	3.00	3.30	117.9	123.6	0.9665	1.0137
5.500	0.375	2.75	2.90	112.8	115.9	0.9254	0.9503
6.000	0.125	2.65	2.70	110.8	111.8	0.9084	0.9169
6.500	0.625	2.80	2.65	113.9	110.8	0.9337	0.9084
7.000	1.125	3.30	2.90	123.6	115.9	1.0137	0.9503
7.500	1.625	3.80	3.25	132.6	122.7	1.0878	1.0060
8.000	2.125	4.60	3.55	145.9	128.2	1.1968	1.0514
8.500	2.625	5.30	3.55	156.7	128.2	1.2846	1.0514
9.000	3.125	6.50	3.15	173.5	120.8	1.4227	0.9904
9.500	3.625	6.50	2.70	173.5	111.8	1.4227	0.9169
10.000	4.125	5.80	2.20	163.9	100.9	1.3439	0.8277
10.500	4.625	4.40	1.80	142.7	91.3	1.1705	0.7486
11.000	5.125	3.30	1.40	123.6	80.5	1.0137	0.6602
11.500	5.625	2.30	1.00	103.2	68.0	0.8463	0.5580
11.750	5.875	2.10	0.80	98.6	60.9	0.8086	0.4991

INTEGRATED FLOW RATE = 91.83 CU.FT/SEC
= 6.638 LBM/SEC

AVERAGE VELOCITY = 121.94 FT/SEC

PRIMARY FLOW RATE, WP = 3.777 LBM/SEC

PRIMARY VELOCITY, UP = 214.24 FT/SEC

MOMENTUM FACTOR, KM = 1.050

(d) S/D= 0.50; UPT Mach No.= 0.064

TABLE XII. Continued.

DATA TAKEN ON 15 JULY 1977 BY MIKE MOSS

4 NOZZLE: S/D= 0.75: L/D= 2.0: MACH NO. = 0.063

AMBIENT PRESSURE = 29.880 IN.HGA, TEMPERATURE = 86.0 DEG.FAHR

PRIMARY (UPTAKE) TEMPERATURE = 119.0 DEG.FAHR

X INCHES	R	PTA IN.H2O	PTB	VA FT/SEC	VB	VA/VAV	VB/VAV
0.0	5.875	3.85	1.35	135.6	80.3	1.0786	0.6387
0.500	5.375	3.95	1.50	137.3	84.6	1.0925	0.6732
1.000	4.875	5.15	1.75	156.8	91.4	1.2475	0.7272
1.500	4.375	6.00	2.00	169.3	97.7	1.3465	0.7774
2.000	3.875	6.35	2.30	174.1	104.8	1.3852	0.8337
2.500	3.375	6.00	3.00	169.3	119.7	1.3465	0.9521
3.000	2.875	5.40	3.20	160.6	123.6	1.2774	0.9833
3.500	2.375	4.50	3.70	146.6	132.9	1.1661	1.0574
4.000	1.875	4.20	3.90	141.6	136.5	1.1266	1.0856
4.500	1.375	3.70	3.75	132.9	133.8	1.0574	1.0645
5.000	0.875	3.50	3.60	129.3	131.1	1.0284	1.0430
5.500	0.375	3.35	3.35	126.5	126.5	1.0[illegible]	1.0061
6.000	0.125	3.35	3.35	126.5	126.5	1.0061	1.0061
6.500	0.625	3.50	3.50	129.3	129.3	1.0284	1.0284
7.000	1.125	4.00	3.65	138.2	132.0	1.0994	1.0502
7.500	1.625	4.40	4.00	144.9	138.2	1.1531	1.0994
8.000	2.125	4.85	3.70	152.2	132.9	1.2106	1.0574
8.500	2.625	5.60	3.60	163.5	131.1	1.3008	1.0430
9.000	3.125	5.95	3.10	168.6	121.7	1.3409	0.9679
9.500	3.625	6.10	2.50	170.7	109.3	1.3577	0.8692
10.000	4.125	5.45	2.10	161.3	100.1	1.2833	0.7966
10.500	4.625	4.30	1.70	143.3	90.1	1.1399	0.7167
11.000	5.125	3.30	1.30	125.5	78.8	0.9986	0.6268
11.500	5.625	2.30	1.20	104.8	75.7	0.8337	0.6022
11.750	5.875	1.95	0.95	96.5	67.4	0.7676	0.5358

INTEGRATED FLOW RATE = 94.66 CU.FT/SEC
= 6.635 LBM/SEC

AVERAGE VELOCITY = 125.70 FT/SEC

PRIMARY FLOW RATE, WP = 3.720 LBM/SEC

PRIMARY VELOCITY, UP = 216.43 FT/SEC

MOMENTUM FACTOR, KM = 1.039

(e) S/D= 0.75; UPT Mach No.= 0.064

TABLE XII. Continued.

DATA TAKEN ON 15 JULY 1977 BY MIKE MOSS

4 NOZZLE: S/D= 1.00; L/D= 2.0; MACH NO. = 0.063

AMBIENT PRESSURE = 29.880 IN.HGA, TEMPERATURE = 84.0 DEG.FAHR

PRIMARY (UPTAKE) TEMPERATURE = 122.0 DEG.FAHR

X	R	PTA	PTB	VA	VB	VA/VAV	VB/VAV
INCHES		IN.H2O		FT/SEC			
0.0	5.875	3.80	1.40	134.8	81.8	1.0663	0.6472
0.500	5.375	4.30	1.70	143.4	90.2	1.1343	0.7132
1.000	4.875	5.20	1.90	157.7	95.3	1.2473	0.7540
1.500	4.375	5.60	2.20	163.6	102.6	1.2944	0.8113
2.000	3.875	5.75	2.60	165.8	111.5	1.3116	0.8820
2.500	3.375	5.40	2.90	160.7	117.8	1.2711	0.9315
3.000	2.875	4.85	3.30	152.3	125.6	1.2046	0.9936
3.500	2.375	4.40	3.55	145.1	130.3	1.1474	1.0306
4.000	1.875	4.10	3.70	140.0	133.0	1.1076	1.0521
4.500	1.375	3.70	3.75	133.0	133.9	1.0521	1.0592
5.000	0.875	3.70	3.65	133.0	132.1	1.0521	1.0450
5.500	0.375	3.60	3.65	131.2	132.1	1.0378	1.0450
6.000	0.125	3.85	3.65	135.7	132.1	1.0733	1.0450
6.500	0.625	4.00	3.80	138.3	134.8	1.0940	1.0663
7.000	1.125	4.30	3.90	143.4	136.6	1.1343	1.0802
7.500	1.625	4.60	4.00	148.3	138.3	1.1732	1.0940
8.000	2.125	5.00	3.70	154.6	133.0	1.2231	1.0521
8.500	2.625	5.40	3.40	160.7	127.5	1.2711	1.0086
9.000	3.125	5.60	3.00	163.6	119.8	1.2944	0.9474
9.500	3.625	5.40	2.50	160.7	109.3	1.2711	0.8649
10.000	4.125	4.80	2.10	151.5	100.2	1.1984	0.7927
10.500	4.625	4.10	1.90	140.0	95.3	1.1076	0.7540
11.000	5.125	3.30	1.80	125.6	92.8	0.9936	0.7339
11.500	5.625	2.60	1.40	111.5	81.8	0.8820	0.6472
11.750	5.875	2.00	1.20	97.8	75.8	0.7736	0.5992

INTEGRATED FLOW RATE = 95.20 CU.FT/SEC
= 6.663 LBM/SEC

AVERAGE VELOCITY = 126.43 FT/SEC

PRIMARY FLOW RATE, WP = 3.709 LBM/SEC

PRIMARY VELOCITY, UP = 216.94 FT/SEC

MOMENTUM FACTOR, KM = 1.028

(f) S/D= 1.0; UPT Mach No.= 0.064

TABLE XII. Continued.

DATA TAKEN ON 4 AUGUST 1977 BY MIKE MOSS

4 NOZZLE: S/D=-.25: L/D= 2.0: WITH TRANSITION: MACH NO. = .063

AMBIENT PRESSURE = 29.840 IN.HGA, TEMPERATURE = 74.0 DEG.FAHR

PRIMARY (UPTAKE) TEMPERATURE = 112.0 DEG.FAHR

X INCHES	R	PTA IN.H2O	PTB	VA FT/SEC	VB	VA/VAV	VB/VAV
0.0	5.875	1.70	0.05	89.4	15.3	0.8278	0.1420
0.500	5.375	2.50	0.10	108.4	21.7	1.0039	0.2008
1.000	4.875	4.10	0.15	138.9	26.6	1.2856	0.2459
1.500	4.375	5.90	0.30	166.6	37.6	1.5422	0.3478
2.000	3.875	8.00	0.60	194.0	53.1	1.7958	0.4918
2.500	3.375	8.80	1.30	203.5	78.2	1.8835	0.7239
3.000	2.875	8.20	2.10	196.4	99.4	1.8181	0.9201
3.500	2.375	6.60	2.80	176.2	114.8	1.6311	1.0624
4.000	1.875	4.80	3.20	150.3	122.7	1.3910	1.1358
4.500	1.375	3.80	3.00	133.7	118.8	1.2377	1.0997
5.000	0.875	3.00	2.50	118.8	108.4	1.0997	1.0039
5.500	0.375	2.50	2.30	108.4	104.0	1.0039	0.9629
6.000	0.125	2.30	2.40	104.0	106.3	0.9629	0.9836
6.500	0.625	2.10	2.50	99.4	108.4	0.9201	1.0039
7.000	1.125	2.40	2.50	106.3	108.4	0.9836	1.0039
7.500	1.625	3.20	2.40	122.7	106.3	1.1358	0.9836
8.000	2.125	4.30	2.85	142.2	115.8	1.3166	1.0719
8.500	2.625	6.25	3.10	171.5	120.8	1.5873	1.1179
9.000	3.125	8.25	2.70	197.0	112.7	1.8237	1.0433
9.500	3.625	9.00	2.00	205.8	97.0	1.9048	0.8979
10.000	4.125	8.00	1.20	194.0	75.1	1.7958	0.6955
10.500	4.625	5.40	0.50	159.4	48.5	1.4754	0.4490
11.000	5.125	3.30	0.10	124.6	21.7	1.1534	0.2008
11.500	5.625	2.10	0.05	99.4	15.3	0.9201	0.1420
11.750	5.875	2.00	0.02	97.0	9.7	0.8979	0.0898

INTEGRATED FLOW RATE = 81.34 CU.FT/SEC
= 5.788 LBM/SEC

AVERAGE VELOCITY = 108.02 FT/SEC

PRIMARY FLOW RATE, WP = 3.742 LBM/SEC

PRIMARY VELOCITY, UP = 215.40 FT/SEC

MOMENTUM FACTOR, KM = 1.197

(a) S/D= -0.25; UPT Mach No.= 0.064

TABLE XIII. Tabulated Velocity Profile Data for L/D= 2 With an Entrance Transition

DATA TAKEN ON 4 AUGUST 1977 BY MIKE MOSS

4 NOZZLE: S/D= 0.0: L/D= 2.0: WITH TRANSITION; MACH NO. = .063

AMBIENT PRESSURE = 29.840 IN.HGA, TEMPERATURE = 74.0 DEG.FAHR

PRIMARY (UPTAKE) TEMPERATURE = 111.5 DEG.FAHR

X INCHES	R	PTA IN.H2O	PTB	VA FT/SEC	VB	VA/VAV	VB/VAV
0.0	5.875	1.30	0.10	78.2	21.7	0.6818	0.1891
0.500	5.375	1.70	0.10	89.4	21.7	0.7797	0.1891
1.000	4.875	2.60	0.20	110.6	30.7	0.9642	0.2674
1.500	4.375	4.20	0.50	140.5	48.5	1.2255	0.4228
2.000	3.875	6.60	0.90	176.2	65.0	1.5362	0.5673
2.500	3.375	7.80	1.80	191.5	92.0	1.6701	0.8023
3.000	2.875	8.20	2.50	196.3	108.4	1.7123	0.9455
3.500	2.375	7.30	3.40	185.3	126.4	1.6156	1.1026
4.000	1.875	5.80	3.90	165.1	135.4	1.4401	1.1809
4.500	1.375	4.50	3.70	145.5	131.9	1.2685	1.1502
5.000	0.875	3.70	3.60	131.9	130.1	1.1502	1.1346
5.500	0.375	3.00	3.00	118.8	118.8	1.0357	1.0357
6.000	0.125	2.80	2.80	114.7	114.7	1.0006	1.0006
6.500	0.625	2.60	2.80	110.6	114.7	0.9642	1.0006
7.000	1.125	2.80	2.90	114.7	116.8	1.0006	1.0183
7.500	1.625	2.80	2.90	114.7	116.8	1.0006	1.0183
8.000	2.125	3.50	3.20	128.3	122.7	1.1187	1.0697
8.500	2.625	4.60	3.40	147.1	126.4	1.2825	1.1026
9.000	3.125	6.40	3.40	173.5	126.4	1.5128	1.1026
9.500	3.625	7.90	2.90	192.7	116.8	1.6807	1.0183
10.000	4.125	8.20	2.10	196.3	99.4	1.7123	0.8665
10.500	4.625	6.80	1.30	178.8	78.2	1.5593	0.6818
11.000	5.125	4.70	0.80	148.7	61.3	1.2964	0.5348
11.500	5.625	3.30	0.50	124.6	48.5	1.0863	0.4228
11.750	5.875	2.90	0.30	116.8	37.6	1.0183	0.3275

INTEGRATED FLOW RATE = 86.35 CU.FT/SEC
= 6.147 LBM/SEC

AVERAGE VELOCITY = 114.67 FT/SEC

PRIMARY FLOW RATE, WP = 3.742 LBM/SEC

PRIMARY VELOCITY, UP = 215.21 FT/SEC

MOMENTUM FACTOR, KM = 1.136

(b) S/D= 0.0; UPT Mach No.= 0.064

TABLE XIII. Continued.

DATA TAKEN ON 4 AUGUST 1977 BY MIKE MOSS

4 NOZZLE: S/D= .25: L/D= 2.0: WITH TRANSITION: MACH NO. = .063

AMBIENT PRESSURE = 29.920 IN.HGA. TEMPERATURE = 68.0 DEG.FAHR

PRIMARY (UPTAKE) TEMPERATURE = 110.5 DEG.FAHR

X INCHES	R	PTA IN.H2O	PTB	VA FT/SEC	VB	VA/VAV	VB/VAV
0.0	5.875	3.00	0.80	118.3	61.1	0.9971	0.5149
0.500	5.375	4.00	0.95	136.6	66.6	1.1514	0.5611
1.000	4.875	5.40	1.30	158.7	77.9	1.3378	0.6564
1.500	4.375	6.85	1.90	178.7	94.1	1.5067	0.7935
2.000	3.875	7.30	2.40	184.5	105.8	1.5554	0.8919
2.500	3.375	7.00	3.30	180.7	124.0	1.5231	1.0458
3.000	2.875	6.10	3.90	168.6	134.8	1.4219	1.1369
3.500	2.375	5.20	4.10	155.7	138.3	1.3128	1.1657
4.000	1.875	4.50	4.10	144.8	138.3	1.2212	1.1657
4.500	1.375	3.90	3.70	134.8	131.3	1.1369	1.1074
5.000	0.875	3.50	3.35	127.7	125.0	1.0770	1.0537
5.500	0.375	3.30	3.20	124.0	122.1	1.0458	1.0298
6.000	0.125	3.20	3.20	122.1	122.1	1.0298	1.0298
6.500	0.625	3.35	3.45	125.0	126.8	1.0537	1.0693
7.000	1.125	3.80	3.80	133.1	133.1	1.1222	1.1222
7.500	1.625	4.70	4.10	148.0	138.3	1.2481	1.1657
8.000	2.125	5.90	4.00	165.9	136.6	1.3984	1.1514
8.500	2.625	7.05	3.50	181.3	127.7	1.5286	1.0770
9.000	3.125	7.50	3.00	187.0	118.3	1.5766	0.9971
9.500	3.625	6.70	2.10	176.7	99.0	1.4901	0.8343
10.000	4.125	5.00	1.30	152.7	77.9	1.2873	0.6564
10.500	4.625	3.20	0.75	122.1	59.1	1.0298	0.4986
11.000	5.125	2.10	0.50	99.0	48.3	0.8343	0.4071
11.500	5.625	1.50	0.30	83.6	37.4	0.7051	0.3153
11.750	5.875	1.20	0.20	74.8	30.5	0.6306	0.2575

INTEGRATED FLOW RATE = 89.31 CU.FT/SEC
= 6.412 LBM/SEC

AVERAGE VELOCITY = 118.61 FT/SEC

PRIMARY FLOW RATE, WP = 3.751 LBM/SEC

PRIMARY VELOCITY, UP = 214.76 FT/SEC

MOMENTUM FACTOR, KM = 1.101

(c) S/D= 0.25; UPT Mach No.= 0.064

TABLE XIII. Continued.

DATA TAKEN ON 3 AUGUST 1977 BY MIKE MOSS

4 NOZZLE: S/D= .5; L/D= 2.0; WITH TRANSITION: MACH NO. = .063

AMBIENT PRESSURE = 29.910 IN.HGA, TEMPERATURE = 86.0 DEG.FAHR

PRIMARY (UPTAKE) TEMPERATURE = 122.5 DEG.FAHR

X (INCHES)	R (INCHES)	PTA (IN.H2O)	PTB (IN.H2O)	VA (FT/SEC)	VB (FT/SEC)	VA/VAV	VB/VAV
0.0	5.875	2.50	1.30	109.4	78.9	0.8777	0.6329
0.500	5.375	3.30	1.60	125.7	87.5	1.0084	0.7022
1.000	4.875	4.30	1.85	143.5	94.1	1.1511	0.7551
1.500	4.375	5.40	2.20	160.8	102.6	1.2900	0.8234
2.000	3.875	6.25	2.80	173.0	115.8	1.3878	0.9289
2.500	3.375	6.40	3.40	175.0	127.6	1.4044	1.0236
3.000	2.875	6.10	4.10	170.9	140.1	1.3711	1.1240
3.500	2.375	5.60	4.30	163.7	143.5	1.3137	1.1511
4.000	1.875	5.10	4.40	156.3	145.1	1.2537	1.1644
4.500	1.375	4.65	4.40	149.2	145.1	1.1971	1.1644
5.000	0.875	4.30	4.30	143.5	143.5	1.1511	1.1511
5.500	0.375	4.10	4.30	140.1	143.5	1.1240	1.1511
6.000	0.125	4.10	4.40	140.1	145.1	1.1240	1.1644
6.500	0.625	4.20	4.60	141.8	148.4	1.1377	1.1906
7.000	1.125	4.50	4.80	146.8	151.6	1.1776	1.2162
7.500	1.625	4.95	4.80	153.9	151.6	1.2351	1.2162
8.000	2.125	5.60	4.40	163.7	145.1	1.3137	1.1644
8.500	2.625	6.15	3.70	171.6	133.1	1.3767	1.0678
9.000	3.125	6.50	2.90	176.4	117.8	1.4153	0.9453
9.500	3.625	6.30	2.10	173.7	100.3	1.3934	0.8045
10.000	4.125	5.30	1.40	159.3	81.9	1.2780	0.6568
10.500	4.625	4.10	1.00	140.1	69.2	1.1240	0.5551
11.000	5.125	3.15	0.70	122.8	57.9	0.9853	0.4645
11.500	5.625	2.30	0.50	104.9	48.9	0.8419	0.3925
11.750	5.875	2.10	0.40	100.3	43.8	0.8045	0.3511

INTEGRATED FLOW RATE = 93.85 CU.FT/SEC
= 6.562 LBM/SEC

AVERAGE VELOCITY = 124.64 FT/SEC

PRIMARY FLOW RATE, WP = 3.707 LBM/SEC

PRIMARY VELOCITY, UP = 216.81 FT/SEC

MOMENTUM FACTOR, KM = 1.065

(d) S/D= 0.50; UPT Mach No.= 0.064

TABLE XIII. Continued.

APPENDIX A

FORMULAE

Presented here are the formulae used to obtain the primary and secondary mass flow rates. According to the ASME Power Test Code [6], the general equation for mass flow rate appearing in equation (a)

$$W(\text{lbm/sec}) = (0.12705)\ K\ A\ Y\ F_a[\rho\ \Delta P]^{0.5} \qquad (a)$$

may be used with flow nozzles and square edge orifices provided the flow is subsonic. In the above equation, K (dimensionless) represents the flow coefficient for the metering device and is defined as $K = C\ (1 - \beta^4)^{-0.5}$ where C is the coefficient of discharge and β is the ratio of throat to inlet diameters; $A(\text{in}^2)$ is the total cross sectional area of the metering device; Y (dimensionless) is the expansion factor for the flow; F_a (dimensionless) is the area thermal-expansion factor; $\rho(\text{lbm/ft}^3)$ is the flow mass density; and ΔP (inches H_2O) is the differential pressure across the metering device. Each of these quantities are evaluated, according to the guidelines set forth in Reference [6], for the specific type of flow measuring device used.

Using a square edge orifice for measurement of the primary mass flow rate, the quantities in equation (a) are defined as follows:

1. The flow coefficient K is 0.62 based on a β of 0.502 and a constant coefficient of discharge over the range of flows considered of 0.60.
2. The orifice area is 37.4145 in^2.
3. Corresponding to the range of pressure ratios encountered across the orifice, the expansion factor Y is 0.98.
4. Since the temperature of the metered air is nearly ambient temperature, the thermal expansion factor is essentially 1.0.
5. The primary air mass density ρ_{or} is calculated using the perfect gas relationship with pressure and temperature evaluated upstream of the orifice.

Substituting these values into equation (a) yields

$$W_p \text{ (lbm/sec)} = (2.8882) \left[\rho_{or} \, \Delta P_{or}\right]^{0.5} \qquad \text{(b)}$$

The secondary mass flow rate is measured using long radius flow nozzles for which case the quantities in equation (a) become:

1. For a flow nozzle installed in a plenum, β is approximately zero in which case the flow coefficient is approximately equal to the coefficient of discharge. For the range of secondary flows encountered, the flow coefficient becomes 0.98.
2. A is the sum of the throat areas of the flow nozzles in use.

3. Since the pressure ratios across the flow nozzles are very close to unity, the expansion coefficient Y is 1.0.

4. Since the temperature of the metered air is nearly ambient temperature, the thermal expansion factor is essentially 1.0.

5. The secondary air mass density ρ_s is evaluated using the perfect gas relationship at ambient conditions.

Substituting these values into equation (a) yields the equation for the secondary mass flow rate measured using long radius flow nozzles.

$$W_s \text{ (lbm/sec)} = (0.13451)\ A \left[\rho_s\ \Delta P_s\right]^{0.5} \tag{c}$$

APPENDIX B

CALCULATION OF THE MOMENTUM CORRECTION FACTOR

The momentum correction factor is defined as the ratio of the actual momentum rate to the pseudo-rate based on the bulk-average velocity. Defining the actual momentum as that obtained by integrating over the velocity surface, the momentum correction factor may be written as

$$K_m = \frac{1}{W_m U_m} \int_0^{A_m} U_2^2 \, \rho_2 \, dA \, . \tag{4}$$

The density of the air at the mixing stack exit ρ_2 is a weighted average of the densities of the primary and secondary air flows. Assuming a secondary to primary mass flow ratio of 0.65, which is consistent with experimental results, ρ_2 is expressed as

$$\rho_2 = \rho_{avg.} = \frac{\rho_s}{1.65}\left[0.65 + \frac{T_s}{T_p}\right] . \tag{a}$$

Using this average density of the mixed flow, the mass flow rate leaving the mixing stack may be expressed as

$$W_m = \rho_{avg} \cdot U_m A_m \tag{b}$$

where A has units of ft^2. Combining equations (4) and (b) results in an equation for the momentum correction factor

in terms of the experimentally determined mixing stack exit velocity profiles,

$$K_m = \frac{1}{U_m^2 A_m} \int_0^{A_m} U_2^2 \, dA \, . \qquad \text{(c)}$$

Figure 44 illustrates the orientation of the two velocity traverses.

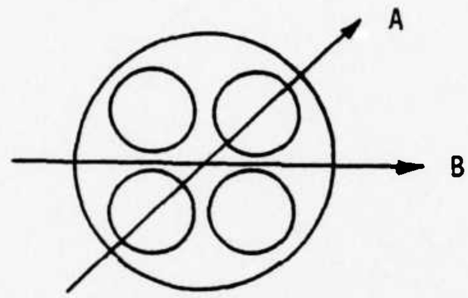


FIGURE 44. Orientation of Mixing Stack Exit Velocity Traverses

To integrate the mixing stack exit velocity over the three-dimensional velocity surface using only the two traverses requires making some approximations:

1. Traverses A and B represent the maximum and minimum values of the velocity surface respectively.
2. The three-dimensional velocity surface is symmetrical, i.e. a velocity traverse passing above the other two primary nozzles, perpendicular to traverse A, is equal to that of traverse A and likewise for traverse B.

3. The circumferential variation of the velocity surface is sinusoidal with the maximum and minimum values at a given radius occurring at traverses A and B respectively.

The velocity traverse obtained experimentally consists of discrete points rather than a continuous curve. Each of these point values of velocity is representative of a radial element of the velocity traverse of length equal to the spacing between successive points. The procedure is to fit a circumferential sinusoidal curve through the maximum and minimum velocities of traverses A and B respectively. Then treat this circumferential band as representing a segment of the velocity surface of incremental width dr equal to the spacing between the data points and integrate circumferentially over successive radial elements. Completion of the integration yields the actual momentum of the mixed gases leaving the exit of the mixing stack.

APPENDIX C

UNCERTAINTY ANALYSIS

The determination of the uncertainties in the experimentally determined pressure coefficients, pumping coefficients and velocity profiles was made using the method described by Kline and McClintock [17]. The uncertainties obtained by Ellin [1] using the second order equation suggested by Kline and McClintock [17] are all applicable to the experimental work reported herein and are summarized in the following table.

TABLE XIV
UNCERTAINTY IN MEASURED VALUES

T_s	± 1 °R
T_p	± 1 °R
P_a	± 0.01 psia
ΔP	± 0.01 in. H_2O
P_V	± 0.01 in. H_2O
P_u	± 0.05 in. H_2O
ΔP_s (†)	± 0.01 in. H_2O
P_{or}	± 0.01 in. H_2O
ΔP_{or}	± 0.20 in. H_2O
T_{or}	± 1 °R
T_a	± 1 °R
PT (††)	± .1 in. H_2O

UNCERTAINTY IN CALCULATED VALUES

$\frac{\Delta P^*}{T^*}$	1.9 %
$W^*T^{*0.44}$	1.4 %
V/V_{avg}	2.5 %

(†) The pressure differential across the secondary flow nozzles, ΔP_s, is the major source of uncertainty in the pumping coefficient.

(††) The measurement of the total pressure for the velocity profile is the major source of uncertainty in the velocity calculation

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2004 Cloverleaf Place
Ardmore, Oklahoma 73401

12. Lt. C. M. Moss 1
625 Midway Road
Powder Springs, Georgia 30073

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